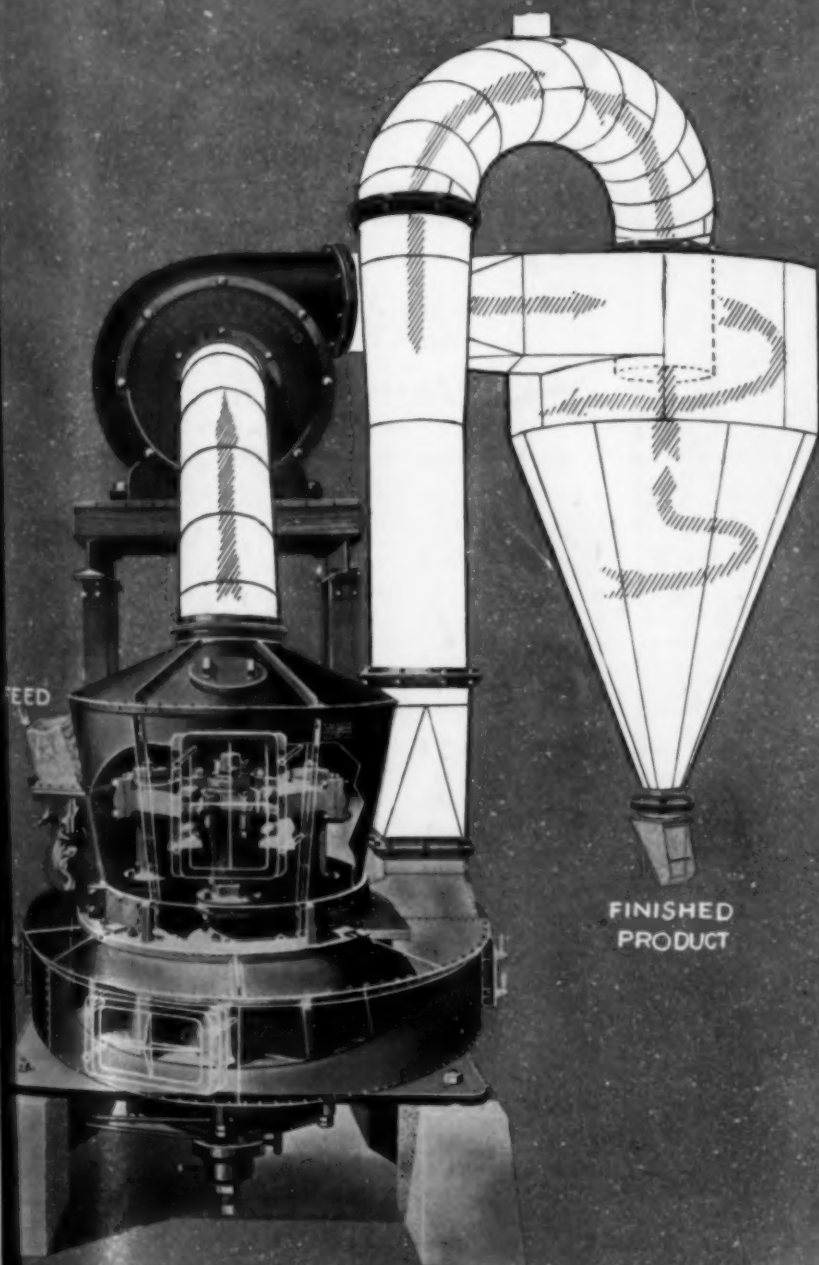


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Metallurgical & Chemical Engineering

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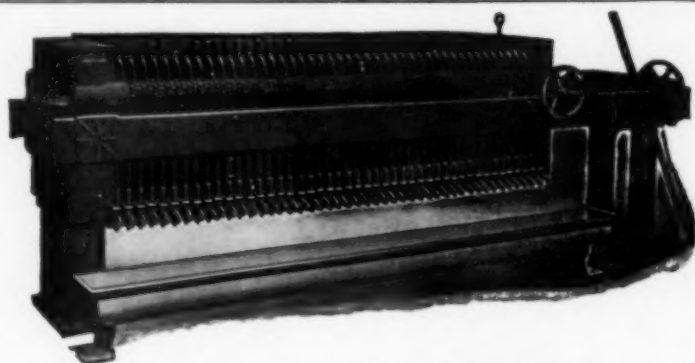
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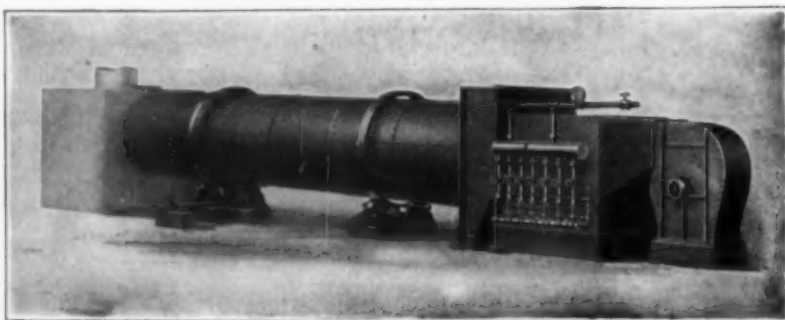
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Doctor Roeber

A quiet funeral in a little house in East Orange, the body of its gentle master at rest among flowers in the parlor, the conventional service of death and the benediction—and the leaf of the big book was turned. Just a few words in ecclesiastical monotone—and everything so different. The machinery mumbles on, the presses revolve, the paper is whisked back and forth in the manner appointed, everything proceeds as before, but somehow the heart of it is still, and all the rest of us, major and minor parts of the organization, are benumbed for the time. We are catching our breath for a fresh start. Of course, the paper will continue; it will look the same and serve the same purpose, because it was planned unto whatever merit it has by one who had a great gift for this very thing.

Now let us consider what manner of man this was, who infused so strong a personality into his editorial work that the paper was almost as frequently spoken of as "Roeber's Journal" as by its printed title. Although he occupied posts of distinction, had been president of the American Electrochemical Society, of which he was one of the founders, and associated with many men of high repute on important committees, his acquaintance among men was far slighter than his influence over them. This was in part because his influence was widespread and in part because of his unusual modesty and extraordinary sensitiveness, which he had in greater measure than was compatible with comfort.

He was a little, round man with a round chin, round spectacles and a big round hat designed for a Texas sombrero, but which on his head straightway became *ein Professorenhut*. He was German born—anybody could see that—but his was the kind that those of us who knew Germany best before the war still love despite everything. And he was a thoroughly sound, patriotic, loyal American citizen without any reservation. He believed in everybody, had faith in everybody and a good word for everybody. There was such kindness and goodwill in his greeting, in his unflinching, believing, encouraging look that the very thought that those gentle blue eyes are dimmed for all time bites into the heart.

The man on the street or in the railway car did not know these things, and so sometimes he was taken for an enemy alien—our editor—whose father and grandfather had opposed Prussianism all their lives and who himself had left Germany because of it. But the slightest unfriendly glance, or the tone of a word spoken in scorn were enough to give him acute pain. Rarely have we known a mortal with such hair-trigger sensitiveness. Nevertheless, he would not let it hinder

him from digging into the day's work or from bearing the sting of it in silence. We verily believe that this shortened his life.

In his office, at his desk, he was a different man. There command was easy to him and there was no hesitation in his decisions. When well-wishers urged him to avoid printing articles with mathematical developments beyond the reach of most readers, he would smile, shake his head—and print in full. If a fair word about labor might offend someone who had neglected to provide for the life, liberty and pursuit of happiness of employees, he would chuckle—and print it. Neither conventional ethics nor philosophy frightened him. He edited a technical paper, but he never forgot the human factor in applied science and industry. When he felt that something needed to be said, he had no interest in minor consequences. He had confidence in his own wisdom, and Wisdom herself was justified in him. He was gracious in receiving advice, but independent in his conclusions. To think or to decide—and decide aright—was neither hard nor painful to him. He was a master at his profession and he breathed the breath of life into his work.

In taking up the burden that has fallen from his shoulders, the editors and publishers are not concerned about articles, or their arrangement, or about comment on things of interest, or advertisements, for these are all provided for. The burden of our hope is that we may attain the same at-homeness in the work and the same cordial goodwill of our readers that the late Dr. Roeber both won and enjoyed. Peace to his memory.

Société de Chimie Industrielle

During the present international complications it is essential that we should not be so preoccupied with problems demanding immediate solution as to lose perspective of our future industrial life. It is a time for the encouragement of forward-looking movements that are concerned with post-war conditions and with the inevitable readjustment that will then take place in international life. And what more logical development than that the bonds of mutual interest in times of peace be most firmly cemented among the nations now allied in common military defense?

Since the entrance of the United States into the war we have received and entertained a number of missions from the allied European countries sent here for the purpose of study. Of these none has been more graciously received than the French Scientific Mission, which is here to investigate our chemical industries and impart as well as receive information and advice. France having realized fully the importance of chemistry in the war, the progress which her enemy neighbor has made in the science and her own loss of the position of honor therein which she formerly occupied, has determined to regain her place and again become a great national exponent of industrial chemistry.

To this end her leading scientists have recently organized the Société de Chimie Industrielle, similar in

purpose to the better known Society of Chemical Industry in England. With the arrival of the French Scientific Mission in this country, some of our chemists were inspired with a patriotic desire to forward the French movement by organizing an American Section of the Société, and thus lay the foundation for future profitable intercourse.

If we read the future aright, French is to be an important language to the progressive American industrial chemist, and French chemical literature will be an exponent of progress. American chemists in increasing numbers will find congenial employment in France, and the relations of the two nations will be enhanced by intimate association with the Société. It remains for us on this side to promote the solidarity of the profession by ardent support of the new organization.

High Prices and Production

It is gradually dawning upon the consciousness of the average American that the present high prices of all commodities are by no means stimulating production in the heralded volume. Prices for coal, for instance, have been fixed at figures quite exorbitant if viewed from the pre-war standpoint, and yet the Geological Survey is recording a practically stationary production, and the newspapers report stories of fuel famines. As noted elsewhere in this issue, Joplin mines which formerly were profitable on \$40 ore, were closed when ore recently declined to \$70. Copper production has been seriously curtailed even though its price has been above 23½ cents for months. The relation of output to price at times even seems to follow that curious anomaly in the labor market; that is, the higher the daily wage the lower the production per man-hour.

The reason is not so very obscure. High commodity prices mean economy in consumption and waste in production, while low commodity prices mean the opposite. With high prices the ultimate consumer gets along with less than he really needs, and even then his finances can hardly bear the strain; the manufacturer at the same time need make no effort to produce in an economical manner, for the price he receives for his output will cover a multitude of sins of omission and commission, and even then leave a very encouraging cash balance. That is to say, they did! To-day, however, all his fellow-producers have gone and done likewise; all his low-priced stock of raw materials and repair parts is exhausted; his total expense for labor, everything, is increasing so rapidly that it overtops the income; a red figure appears on the balance sheet, and the factory closes.

Is it not that America needs a spiritual awakening? War is a hard taskmaster, and yet Mars may furnish the leaven which in time will ferment the entire body. For there are countless young men now serving their country, leaving behind their positions, their salaries, their hopes for preferment—everything that seems best to them. Money means little to them now; it will

mean less ere they happily return. May they come back fire-refined, with a purer and better outlook and more stable sense of the eternal fitness of things, to instruct the stay-at-homes by their noble example.

Future of Iron and Steel Prices

A measure of price control has now been established for the iron and steel industry. It has been accomplished by agreement between the Government and the producers. Specific maximum prices have been set for certain products, while there is an understanding that prices for other commodities are expected to be adjusted to the same general basis by voluntary action on the part of producers.

It is not difficult to compare the price level as established or being established with average prices of the past, for the reason that average prices over various periods of years have not varied greatly. The iron and steel market has had great ups and downs, but the round trip movement has been confined to relatively short periods, and there are various periods of years, long and short, that have shown substantially the same average. A fair representative period is the ten years, 1904 to 1913, inclusive, containing about the usual sprinkling of good and bad years, and showing averages not greatly different from those of many other periods. Generally speaking, the new prices are just a trifle more than double the average prices in that period. Unfinished steel is a trifle less, but pig iron is about 110 per cent higher and the finished steel products average about the same amount.

The transition from the open market, with extremely fancy prices produced by buyers bidding against each other for relatively small prompt lots, to a more or less regulated and a much better defined market, has proceeded with much less confusion than might have been expected. It occurred, fortunately, at a time when the market was extremely dull and there was not much disposition to do business.

With this transition largely accomplished the trade has turned quickly to a consideration of the question, what is to be the trend of steel prices in the future. The first price announcements at Washington specifically stated that the set prices were subject to modification Jan. 1, 1918. It is the common view of the trade that if the market level changes in future the change will be downwards. The Government might, in accordance with its suggestion, set lower prices on Jan. 1, or later, or the market might of its own accord decline to lower levels, as, of course, the prescribed prices are maximum only. However, the steel trade has had a great deal of experience in the past in adhering to certain prices, once fixed. It was illegal for the makers to meet and adopt prices, or even to agree to maintain prices, but when prices were well established there was nothing to prevent the producers, acting as individuals, from departing from the established schedule. It appears to be the common idea that if the steel market should develop some weakness as to the relation between supplies and requirements, the producers would be slow to depart

from the established maximum figures, but would hold to them as long as possible.

It is almost inconceivable that conditions in the United States as to steel should conform to those developed in England after more than three years of war. England has been converted into a vast arsenal. There is practically no peace steel being manufactured. England, however, is producing about 8,000,000 tons of finished rolled steel a year, while the United States is producing four times as much. England is supplying France to a very considerable extent, the French steel production being only in the neighborhood of one-half the British production. With such indices as to the war-steel requirements of great nations it is difficult to see how the United States can find means of employing its very much larger steel production entirely for war purposes. The means for converting the steel, as it leaves the steel mill, into the various means for prosecuting war must be found. It is a question between the prosecution of war calling for steel and the prosecution of war decreasing the peace consumption of steel.

The more the country at large devotes itself to war, in consuming or fabricating steel for that purpose, the more it leaves the arts of peace that consume steel. One thing is obvious, and it may prove to be the governing factor in determining the relation, a few months hence, between the supply of steel and the requirements, and that is that the railroads are always a necessary and great factor in determining the requirements that are put upon the steel industry. Without fairly heavy buying on the part of the railroads the steel industry is never active. Certainly, when the full prosecution of the war depends so much upon full transportation facilities being maintained, one could not imagine a condition of the railroads not taking steel and other consuming industries taking it freely.

The position of the railroads is particularly in doubt at this time. They have been handling a vastly greater volume of freight than ever before in their history, with practically no larger amount of rolling stock than at any previous time. Winter, however, is approaching and in bad weather the effectiveness of railway facilities always decreases. The railroads, apparently, are not in mood to buy at present prices, even though they represent a substantial reduction, for they are still at least double the previous average. The 15 per cent rate advance case is reopened, with hearings to begin before the Interstate Commerce Commission on November 5. The large question, whether the commission will consider it in that form or not, is whether the gold dollar has greatly depreciated. If it has, then railway rates being fixed in dollars ought to be advanced, for wages and commodities generally have advanced. A substantial rate advance may be granted, while there is an alternative suggested, that the Government undertake to finance the railroads. Many railroad managers, however, explain very practically that what they want to do is to make money, not borrow it.

Eugene Franz Roeber

DR. E. F. ROEBER, editor of METALLURGICAL & CHEMICAL ENGINEERING, died at his home in East Orange, N. J., Oct. 17, 1917, after a lingering illness of several months. He had not enjoyed the best of health for a year or more, but it was not until last June that he was compelled to leave his work, to which he never returned. For some time it was hoped that complete relief from care and responsibility, coupled with the best of medical care and attention, would restore him to health and activity, but he failed steadily, and came to an untimely end in the prime of life.

DR. ROEBER was born in Torgau, Saxony, Oct. 7, 1867, and passed his fiftieth birthday ten days prior to his death. His excellent education in science and engineering was received at three German universities, Jena, Halle and Berlin. At the last institution he received the degree of Doctor of Philosophy in 1892. Without waiting to find a field for his abilities in his native country, he came to the United States in 1894. For several years he remained in comparative obscurity, and for part of that time at least was associated with the book concern of Steiger in New York.

In 1899 he made the acquaintance of Dr. Carl Hering of Philadelphia, who engaged him as an assistant, and he removed to Philadelphia. This was his first professional engagement, and marked the beginning of a notable career in electrochemistry which led to his recognition as a leader. His work was characteristically thorough, reliable and conscientious, qualities which he later applied with such success as a technical editor, and which first became apparent in his digest of foreign literature for the *Electrical World*, published in New York.

The early days in Philadelphia witnessed two important undertakings in which DR. ROEBER played an important part. It was then that electrochemistry was assuming an aspect of importance in this country, and the time seemed opportune to publish a journalistic exponent for the industry. Accordingly, *Electrochemical Industry* was established as a monthly publication in September, 1902, with DR. ROEBER as editor. It was

edited at Philadelphia until June, 1903, when the office was removed to New York. Under his editorial guidance the magazine grew in importance and influence, and in January, 1905, it assumed a broader field of activity under the title *Electrochemical and Metallurgical Industry*. In 1906 came the absorption of the *Iron and Steel Magazine*, and in January, 1910, there was a further expansion of the field served by the magazine to include the general realm indicated by the present title, METALLURGICAL AND CHEMICAL ENGINEERING. Through all of these logical developments DR. ROEBER remained as editor, directing the policies and enlarging the field of service of the magazine which stands as a fitting tribute to his ability.

The other project, initiated in Philadelphia about the same time, was the organization of the American Electrochemical Society. This developed from the close association of DR. ROEBER with C. J. Reed, Carl Hering and others, and had its inception in the informal gatherings and discussions of that group. DR. ROEBER'S enthusiasm and encouragement in the organization and continued support of that society was responsible in large

measure for its success and present influence. It must now be a matter of gratification to its members to know that they honored him with the presidency in 1913-14.

He had a wide interest in science and engineering and a broad knowledge of both. This, coupled with an unusual ability to express himself in a pleasing literary style, gave his own writings a tone of authority and confidence, and enabled him to choose wisely from the contributions of others. In speech, his English was broken, but in writing it was exact and fluent. This was because he early recognized the demand which the editorial profession made upon him, and he applied himself to it with characteristic thoroughness. His services, therefore, were in demand by publication committees and library boards of several technical societies. His wide interest in science and engineering was evidenced by membership in the American Electrochemical Society, American Institute of Mining Engi-



neers, American Chemical Society, American Institute of Electrical Engineers, American Institute of Chemical Engineers, and Society of Chemical Industry. He was a member also of the Chemists' Club, New York.

The high personal regard in which he was held by his professional friends was evidenced in many ways, but probably with no more kindly and sincere token than the silver loving cup which was presented to him during his presidency of the American Electrochemical Society. This represented the loving tribute of a large

number of friends and admirers throughout the country, who gladly responded to the proposal made by Dr. L. H. Baekeland.

While still living in Philadelphia, Dr. ROEBER married Miss Clara H. Feir of New York, the ceremony being performed in Hoboken, N. J., May 6, 1900. He continued to make his home in Philadelphia until 1903, when he removed to New York. He is survived by his widow and three sons, Edward and Bert, aged 11, and Robert, aged 4.

Personal Tributes

BY CARL HERING

THE writer claims the honor of having "discovered" Dr. Roeber; it was in 1899, when he was doing clerical work in a book store in New York. He was a total stranger to me, but a few minutes' talk with him convinced me that he had an exceptionally good education and was a man of rare abilities, and I considered myself fortunate in being able to secure him as my assistant, which position he held until about 1903. It was his first professional position, he having only recently come to this country.

His excellent and thorough training in the fundamentals of physics in general, and electricity and electrochemistry in particular, encouraged us, in cooperation with Mr. Weaver and Mr. McGraw, to start the monthly journal, *Electrochemical Industry* (later METALLURGICAL AND CHEMICAL ENGINEERING) in September, 1902, making him the editor. It was edited for its first year from my office, and he was its able editor from that time to his death.

The highly interesting and instructive discussions on electrochemistry in the evenings with him and C. J. Reed led us to initiate the formation of the present national electrochemical society. Had it not been for his encouragement, both of these eminently successful ventures, the journal and the electrochemical society, might not have been started.

His work, even when difficult, could be relied upon absolutely, never requiring any supervision; he never made mistakes in his calculations. His unostentatious modesty gave one an incorrect impression of his latent abilities.

He was an indefatigable worker, conscientious and thorough to an extreme, always ready and willing to do hard work—the harder it was the more it interested him. His great ambition was to do his work well. It was his willingness to assume more work than his health warranted that led to the untimely ending of his career.

The final balance in which a completed life is weighed is one which measures the good which has been done during that life. In this balance his useful, prematurely terminated life outweighs that of many of his co-workers.

As a friend he was always true and loyal. Personally I feel that I have lost one of my highly esteemed and most valued personal friends.

Philadelphia, Pa.

BY ARTHUR D. LITTLE

THE death of Dr. E. F. Roeber at an age which connotes ripe experience and many years of prospective usefulness brings deep regret to all who knew him and is a real and serious misfortune to American science and technology. Great editors are rare in any department of intellectual activity. They are most exceptional among technologists, and Dr. Roeber was a great technical editor. He possessed the broad foundation of exact knowledge which gave weight to what he said, and the literary ability to say what he wished effectively. He had the sense of timeliness, the critical faculty for appraising values, and a fine enthusiasm which verified and rendered notable the publication under his control. He assumed his editorial duties at a time when applied chemistry in this country was peculiarly in need of encouragement and expression, and he discharged these duties so effectively and even brilliantly as to place all American technologists in his debt.

Dr. Roeber had a singularly sensitive and kindly nature which evoked response in all who came in contact with him and by them he will always be remembered with affection.

Boston, Mass.

BY WILDER D. BANCROFT

ROEBER'S career is a wonderful confirmation of the cherished belief that in America each man will somehow get a chance to develop his particular talents. When he came to this country he had in him the makings of a great editor; but it is doubtful whether he knew this, and it is certain that nobody else did. He happened to be associated with several of the men who founded the American Electrochemical Society, and when an enterprising publishing firm started *Electrochemical Industry* he was made editor of the new journal. It seemed probable at the time that he was expected to do the hard work and not to furnish the editorial brains; but this was his opportunity and he made the most of it. What he has done is written large for the world to read. We can only guess what he might have done had he been spared. To accomplish what he did required not only great ability, but a sterling character, and Roeber had both. The surviving members of the Electrochemical Society may well be thankful that they were able to show their appreciation of his work by electing him president.

Ithaca, N. Y.

BY JOSEPH W. RICHARDS

OUR beloved friend united the best qualities of German thoroughness with the finest sort of American enlightenment and progressiveness. It was an incomparable combination. He wrote such English in his editorials as is scarcely matched by the best technical writers; his style was admirable. And there breathed through all his writing a broad spirit of tolerance, brotherly kindness and helpfulness. On every question of present interest in chemistry and metallurgy he took a point of view which was inspiring to his co-workers and educative to the technical public.

And then his ability to get people to pull together; to induce them to impart their experience in written articles for the general benefit of the profession; his unerring judgment on the fitness and the timeliness of technical communications and discussions! For fifteen years chemistry and metallurgy, and particularly electrochemistry, have been accumulating a debt to his activity and personality which is second to its obligation to none other. Not only the United States and Canada, but Europe was his debtor. His beloved journal, the pride and the glory of his career, was better known (and possibly more appreciated) in Europe than in America. It was known as "Roeber's journal." What greater tribute can there be paid to his being the inspiring soul of this magnificent technical periodical. It is his monument, and will perpetuate his memory, his tireless energy, his wonderful assistance in the technical development of his adopted country, and in its leadership in world affairs. We can all regret the loss to the world of technical journalism which his death means, and deplore the cutting off of his activities, but we can just as sincerely and intensely rejoice that we had the stimulus of his leadership and the privilege of his comradeship during fifteen long and notable years—the best years which applied science has ever experienced.

South Bethlehem, Pa.

BY L. H. BAEKELAND

DR. Roeber appeared among us some seventeen years ago. Modest to the point of bashfulness, yet cheerful and enthusiastic, he soon became, through his abilities, knowledge and intense work, an active element among that group of men who set the ball rolling in the development of our electrochemical industries. This same group of men made of the American Electrochemical Society the great constructive organization which it is to-day.

He put his whole personality and talent in the editorship of METALLURGICAL AND CHEMICAL ENGINEERING, née "*Electrochemical Industry*," but more fitly named by his friends by the shorter, unofficial title "Roeber's Magazine." One day he told me that his main aim in life was to build up his publication to be the best in its line. He most certainly succeeded in this, and erected his own monument thereby, teaching at the same time to others how to publish a journal of applied science. He showed the American Chemical Society along what lines it should publish the Journal of Industrial and Engineering Chemistry, which followed him as a guide and as a pace-maker.

In the meantime, he lived a modest life along the

principles of plain living and high thinking, never putting his personal interests in the foreground, yet fearless and outspoken whenever it came to a matter of responsibility, duty or justice.

Whoever has known Roeber can never forget him; they also realize how the events of this war preyed on his mind and hastened his untimely end. A thorough lover of his adopted country, a firm believer in America's great mission for democracy, he suffered in silence at every crime perpetrated by those who are leading his native Germany into the Great Abyss. His friends respected his agonies and they saw in him another living argument that even modern Germany sent us some men whose souls are clean and free and generous.

Yonkers, N. Y.

BY W. R. WHITNEY

IN the death of Dr. Roeber, American electrochemists have lost one of the most forward-looking of their number. Active and constructive, agreeable and appreciative, he was most generally known and esteemed. In his quiet way he did a great deal toward establishing conditions of understanding between our scientists and our engineers. We know what service he gave to the American Electrochemical Society in its establishment and by never-tiring support, and we know how he built up his journal, METALLURGICAL AND CHEMICAL ENGINEERING. But these are only the general expressions which must come to the minds of thousands of American chemists.

To me personally, when I think of Dr. Roeber, these seem his minor points. We loved him heartily for the man we found in him. We never saw him when he was not ready to bubble over with enthusiasm in support of any good thing. He was independent in thought, but this never interfered with his good nature and co-operation. He kept his worries buried beneath a smile. Born in Germany, he was no less a loyal citizen of this country. The mental anguish which he must have felt during the past three years was seldom shown or expressed, but we know how he suffered, because we knew his highly sensitive and lovable makeup. This sad but successful trial of his character was greater than any of us can possibly appreciate, yet he never faltered. To me he was a perfect American citizen with a strong heart broken for his fatherland. We shall class him with those who, whether in arms or no, have proved themselves heroes.

Schenectady, N. Y.

Southern Meeting Planned for American Electrochemical Society

It is believed that unusual interest will attach to the meeting of the American Electrochemical Society in the spring of 1918 through the opportunity that will be afforded to visit the rapidly developing industrial centers of the South. Plans laid last week by the directors provide for a week's trip by special train through Tennessee and Alabama. The party will be organized at Washington, D. C., and one day will be spent in the vicinity of each of the following centers: Kingsport, Knoxville and Chattanooga, Tenn.; Sheffield and Birmingham, Ala.

Kingsport, Tenn., is a self-contained industrial center, manufacturing electrolytic chlorine, leather,

glass and dyestuffs. At Knoxville there will be an opportunity to see some new and important hydroelectric developments on a large scale. Chattanooga will be an interesting point on account of its water-power development and possibilities, manufacture of ferrosilicon and the concentration and smelting of zinc ores.

One of the most interesting features will be a visit to Muscle Shoals at Sheffield, Ala., which is the site of the Government's new nitrate plant. Here there will be a hydroelectric development of 500,000 hp., with possibilities for a second development of equal magnitude. The visit to Birmingham will close the trip, and return to Washington will be made from that point. Birmingham is one of the most active Southern industrial centers and is notable for its natural resources in coal, lime and iron.

It is announced that the strongest and most influential forces of the South are taking an active interest in this meeting, and there is every prospect of a mutually profitable trip. The South will acquaint the society with its resources and opportunities, and the society will endeavor to show how those resources can best be utilized in developing electrochemical industry. Technical sessions will be planned for the evenings spent at the various centers.

Although this meeting as planned will be more pretentious and larger than any yet held, it is felt to be timely as well as affording an unexcelled opportunity to see a rapidly developing region of our country. It is anticipated that the expense will not much exceed the cost of transportation and Pullman service.

New York Section of Society of Chemical Industry

The first sectional meeting of the season in New York was held at the Chemists' Club on Friday evening, Oct. 19. It was a joint meeting of the New York Section of the Society of Chemical Industry with the New York Sections of the American Chemical Society and American Electrochemical Society. A dinner preceded the meeting, and a large number were present at both the dinner and the meeting.

Dr. JEROME ALEXANDER of the National Gum & Mica Co., chairman of the New York Section of the Society of Chemical Industry, presided. He opened the meeting with a few remarks on the war situation and the formation of an American section of the French Society of Chemical Industry, and then introduced Dr. M. C. WHITAKER, president of the Chemists' Club. Dr. Whitaker announced that at the last meeting of the club Prof. VICTOR GRIGNARD of the University of Nancy, France, had been elected an honorary member of the Chemists' Club. Dr. Whitaker then introduced Dr. L. H. BAEKELAND as the master of ceremonies in conferring the honor. Dr. Baekeland made a very impressive speech, mostly in French, in which he expressed to Prof. Grignard the great pleasure which it gave him to confer upon him the distinction. He said the French chemists had been too modest in advertising themselves in this country, to their own detriment. The audience rose in acknowledgment of its appreciation when Dr. Baekeland had finished. Professor Grignard responded with an excellent address in French, a translation of which is herewith given in full.

Prof. Grignard's Address

I feel truly perplexed before all the marks of sympathy, all the honors, which have come to me like an avalanche since I put my feet on this beautiful land of America.

From the moment I arrived, even on the ship itself, two of your eminent representatives, Dr. Baekeland and Professor Bogert, kindly put themselves at the disposal of Mr. Engel and myself and offered the hospitality of this house.

Since then, wherever we present ourselves, we have encountered the same enthusiastic welcome, the same sincere desire of being of service to us.

Then again, at the beginning of the month of August, a charming and memorable banquet, even more touching by its intimate cordiality than any great official galas which often are more arranged for the gallery than for the participants, brought us together in this same place.

Then again, that important meeting in Boston, where Professor Stieglitz announced so kindly the great honor which was conferred upon me by the American Chemical Society, and which has been appreciated as much as it was unexpected.

And to-day, gentlemen, you open to me all the big doors of your great house, you welcome me into the intimacy of your home; in a word, you adopt me as a member of your great family.

Let me tell you that this honor impresses me even more than the preceding ones, because there is in this something which touches me more particularly in a personal way.

Undoubtedly I am happy and proud to have been for you an occasion to manifest your sympathies, even your admiration, for France in general, and for French chemistry in particular, but, believe me, I would be less impressed when bringing home from here honor certificates and diplomas if I did not know I am taking home to my country also somewhat of your hearts.

This ceremony proves to me that I am not mistaken in this. Therefore, gentlemen, I desire to express more particularly my profound gratitude, my great happiness, to have been able, notwithstanding my lack of knowledge of the English language, to bring to you the impression that in spite of the sorrows of the present hour French chemistry, like all France, lives and works, and only desires to live and work still more. And we look upon our big American sister as particularly qualified to help us in this work of reconstruction.

Indeed, gentlemen, you possess all that is necessary for this. Thanks to the immensity of your magnificent territory, you have natural forces and mineral riches of the most varied nature, of greatest abundance, and of the most precious kind, which nature has been able to give to any people.

You have the confidence and enthusiasm of youth; you have also the audacity thereof, and fortune, which loves the audacious, smiles upon you. Have you not shown excellent proof of this in the creation and the prosperity of the Chemists' Club? You have banking organizations which know how to favor beginning enterprises; you do not allow yourself to be held back by timid men or by skeptics, and you know how to look forward on a large scale—large, like your beautiful land!

Many of your projects surpass by their audacity the limits of our immediate comprehension. Thus, it has frequently happened in France, at least in certain circles, to try to class such enterprises by saying "It is American bluff." But nothing of the kind. We have to admit it. The bluff resides merely in our imagination. It is not in yours; you look at the world in all the boldness of your imagination, and you dream of realities which sometimes seem to surpass the possibilities of the moment. You have the vision of granddeurs of the future—that is all. But do not let us call this bluff; let us admire it.

What can your older little sister bring you to complete such a powerful *ensemble*? Truly, very little; but, nevertheless, something! A finer sense of truly scientific ways, due to a tradition and an education of older duration; after all, the privilege of seniority is not always enviable, but it may often render its services.

France owes it to this that in many directions, and more particularly in chemistry, she was an innovatrix, and this privilege would have been still more obvious, even to the minds of those who are less informed, if our laboratory men, if our engineers, had had behind them sufficient backing, well equipped laboratories, more elastic budgets, well-informed manufacturers, daring capitalists.

Many new ideas which germinated in France might have grown up there, and might have contributed to make the halo of French science still more brilliant.

For instance, to speak of a question of burning reality, the synthesis of ammonia, which at this moment preoccupies all the Allies, the so-called Haber process is called thus because it has been studied and put in shape in the laboratory of Haber by a Frenchman, Rossignol. It is probable that if Rossignol had possessed in France a laboratory which afforded the resources of that of Haber, France would not be at this moment anxious to procure ammonia, and Germany might perhaps have been short of it long ago. Furthermore, the principle of this process, that is to say the combination of nitrogen and hydrogen under pressure at a sufficiently high temperature, and in presence of a catalyzer, was discovered a long time ago in Paris by our eminent chemist, Le Châtelier.

Unfortunately, the gaseous mixture at one of the tests was ill-prepared and still contained oxygen, and caused the explosion of the apparatus, and the experiments did not go further. We should not think, of course, that when an apparatus blows up it is the French scientist who retreats. No, alas! it is simply his budget which blows up.

And thus was it that the synthesis of ammonia, which ought to have been a French conquest, has taken the aspect of a German discovery.

Well! We know at present in what soil we shall have to plant the good seed. Whenever the old French humus will no longer be deep nor rich enough to permit a rapid and powerful growth, do not let us lose our way among our rapacious Eastern neighbors, who are always on the alert for some new plunder; let us take it to you where we shall find the confidence, the daring perseverance, with all the material and financial resources which can assure success.

In this way, long ago, the inventor of the triple-effect evaporator, when he was misunderstood in his own country, brought to your sugar refiners his in-

genious discovery, which since then has had a splendid development in many industries. It is necessary that a close co-operation on scientific and industrial lines should be organized more and more between our two countries.

The horrible war which has been imposed upon us has already made a big step in that direction.

In order to save the world from Prussian hegemony, in order to stop the grasping hand of Germany over every liberal thought and generous instinct, we cannot have enough of the support of the United States alongside that of the European Allies. And this brotherhood of our armies has made indispensable, more particularly between our two countries, the scientific and industrial alliance which is necessary to conduct this war, a war more scientific than anyone ever imagined.

Without citing too many examples, our metallurgists have already brought to you precious improvements in the manufacture of steel; from your side, you bring us a solution, and perhaps two solutions, to the bothersome nitric acid problem.

This fecund collaboration should continue after our victory. Yesterday we exchanged professors; tomorrow we shall exchange students. Thanks to the zeal of my devoted collaborator, Engel, thanks to the friendly efforts of some among you, quite a number of American chemists have already subscribed their names for membership in the Société de Chimie Industrielle, which recently has been founded in Paris, and I hope that at our return to France, we shall be able to reciprocate and to increase the number of members of the American Chemical Society.

In this way the field shall have been well prepared for the exchange of ideas which will precede our common efforts.

In their own turn, other elements of intimate collaboration will present themselves to reinforce all that exists already, and if I am enabled, within a few years, to visit again your beautiful land, I have the firm conviction that I shall be able to bring then the greetings of a newer France to a still greater America.

* * * *

Mr. J. V. N. DORR, of the Dorr Co., chairman of the New York Section of the American Electrochemical Society, then announced that Dr. E. F. Roeber, editor of METALLURGICAL & CHEMICAL ENGINEERING, had passed away, and spoke a few words of appreciation. He suggested that a committee of three be appointed to draw up resolutions. The suggestion was put in the form of a motion and passed. Dr. Doremus moved a rising tribute to Dr. Roeber, which was accordingly acted on.

An interesting technical program was presented, the first paper being read by W. L. JORDAN of the Kieselgahr Co. of America on recent problems in filtration. He dwelt particularly on the uses of Filter-Cel in the filtration of oils, soaps, glycerine, etc.

Mr. MAXIMILIAN TOCH, of Toch Bros., New York, gave an interesting account of an investigation on the pigments of the tomb of Perneb.

A description and practical demonstration of the Kober-Nephelometer was given by Mr. P. A. KOBER of Albany, N. Y.

"Titanium and Its Industrial Applications" was the subject of a short talk by A. J. Rossi, of the Titanium Alloys Mfg. Co., Niagara Falls, N. Y.

St. Louis Meeting American Institute of Mining Engineers

The latter part of the meeting, the first two days of which were reported in our last issue, page 455, consisted chiefly of an excursion through the zinc and oil fields in southwest Missouri and northeast Oklahoma. Here the local sections of the Institute outdid themselves in entertaining their visitors in every way possible. The coincidence of so many interesting inspection trips with the technical sessions, told heavily on the attendance at the latter. The iron and steel session held at St. Louis on the third day of the meeting was unfortunately attended by a mere handful.

IRON AND STEEL SESSION

Messrs. R. B. SOSMAN and J. C. HOSTETTER of the Geophysical Laboratory presented two papers on certain phases and inferences to be drawn from their studies on artificial and natural oxides of iron. These papers, which are of interest mainly to geologists, will scarcely bear abstracting in this place. They are but another of the remarkable scientific publications from the Carnegie Institution.

HENRY S. RAWDON of the Bureau of Standards read an interesting contribution on "Some Unusual Features in the Microstructure of Wrought Iron." He pointed out that the usual commercial iron contains varying amounts of phosphorus and silicon in solid solution in the ferrite, and the remaining impurities—manganese, silica and sulphur—exist as slag inclusions. The ferrite matrix has the microstructure and appearance of a pure metal, and deep etching reveals nothing but etching pits. In examining a number of wrought iron samples known to be "unsatisfactory," a few of them showed areas of large ferrite crystals of a peculiar mottled appearance, particularly after prolonged etching with 5 to 10 per cent alcoholic solution of nitric acid, or more readily with Stead's reagent (*Journal of the Iron & Steel Institute*, vol. 91, p. 140). By a study of iron-phosphorus alloys this is shown to be caused by non-homogeneous diffusion of the phosphorus into the solid solution. Prolonged heating is necessary to cause a uniform distribution. The fracture of a certain wrought iron eye-bar followed a course nearly parallel to these phosphorus etch-patterns, and an examination of the adjacent metal showed the characteristic slip planes developed by alternating stresses. The effect of the brittle phosphoric ferrite is apparent.

EXCURSION TO MISSOURI AND OKLAHOMA

Wednesday evening, Oct. 10, the entire gathering of Institute members and friends boarded a special train, and the next morning found themselves on the Kansas-Missouri line, where a stop of an hour was made to inspect some steam-shovel operations in the southeast Kansas coal field. Here a gigantic 300-ton Marion shovel was stripping some twenty feet of overburden, six feet of which was a hard shale, to uncover thirty inches of coal. This coal was shovelled into small cars by hand, owing to the numerous "horses" or bands of rock intersecting the seam. About thirty men were idle in the pit during our stay, inasmuch as the mining company had no storage capacity in the tippie, and the railroad company was a little slow in getting in empty cars.

Proceeding, the party arrived at Webb City, Mo., where automobiles took them through the district, stopping first at the new mill of the Oronogo Circle Company, now nearly completed, and representing the latest and best development in this field. From here the automobiles proceeded through the "sheet-ground" district some five miles or more to the other end of the mineralized beds to Cartersville, where luncheon was served at the American Davey Mines. Here an opportunity was given those interested to go underground, while others were toured through Joplin and Galena. Returning to Joplin an interesting session on Zinc was held, GEORGE C. STONE presiding. Later in the evening, the "Miners' Home," a reproduction of a frontier bar-room, was opened in the roof garden of the hotel, and all mining engineers found refreshment and excitement among the fire-eaters, cow-punchers, confidence men and gamblers who infested the place. Numerous prominent members were arrested by the sheriff, as they answered descriptions of sundry bandits, horse-thieves and common murderers, posted around the walls, while twice the occupants were "stuck-up" by desperadoes and relieved of all their "phoney" money. A delightful banquet completed the day's pleasures.

SESSION ON ZINC

"Oxide of Zinc" was the title of the paper read by the chairman, GEORGE C. STONE. This paper has been published in full in *METALLURGICAL AND CHEMICAL ENGINEERING*, Sept. 15, 1917, p. 308, and describes the production of the oxide from Franklinite or Wetherill grades. W. R. INGALLS then presented a short note on "Zinc Burning as a Metallurgical Process." He defined "zinc burning" as a process of igneous concentration wherein the zinc oxide in a furnace charge is reduced to metallic form, volatilized and then burned to zinc oxide, which oxide may be settled or filtered and used as such or as a raw material for further treatment. Mr. Ingalls noted that while zinc burning generally has been effected on Wetherill grades—merely a blast furnace process—it can also be done in blast furnaces (as at Florence, Col.), in reverberatories (as by Frederick Laist at Anaconda, Mont.), or in converters (experimentally by Babe, in Europe). Leaving aside the manufacture of pigment, which requires a product of excessive cleanness, zinc burning has many applications, as follows:

"1. As a simple means of concentrating low-grade ore, especially calamine, to save freight and treatment charges on worthless gangue. Thus, the calamine of Leadville might be taken to Canyon City, Col., the zinc might there be burned off and the zinc oxide shipped to distillers or to electrolytic refiners. This is in fact being done on a small scale.

"2. The residues from lixiviation in electrolytic zinc works, containing a large quantity of zinc owing to the formation of insoluble zinc ferrite in roasting, may be burned on Wetherill grades for the extraction of that zinc. This is going to be done. An ore containing 48 per cent of zinc and yielding 83 per cent of it to sulphuric acid may have a residue assaying 20 per cent zinc, the proportion of residue to original ore (roasted) being about one-third, and that 20 per cent of zinc is well worth extraction.

"3. It is possible that it may be found most economical in the electrolytic process to roast the ore, burn it

on Wetherill grates and subsequently leach the fume.

"4. The production of zinc fume in this way affords an excellent supply of zinc for the manufacture of lithopone and other chemical purposes."

The discussion brought out the further application of treating zinc-retort residues. These residues contain zinc values depending in quantity upon the excellence of roasting and richness of the original concentrate, sometimes running as high as 6 per cent. They also contain sufficient excess carbon to operate a Wetherill grate nicely, and at one plant in Oklahoma a considerable quantity of very excellent pigment is being made from such materials. In the treatment of zinc ores or residues in the blast furnace or reverberatory it is necessary, of course, to reduce the slag losses to as low a point as possible. The zinc is freed from the ore as a volatile metal, in a reducing reaction, and must be held as such until entirely free from the charge. Evidently a slag with oxides of low valency will therefore contain less zinc than otherwise. In this connection it was mentioned that the zinc remaining in a Wetherill clinker was smaller in quantity with a decreasing thickness of charge.

MR. R. G. HALL, general manager of the River Smelting and Refining Co., operating an electrolytic zinc plant at Keokuk, Iowa, presented a paper entitled "Some Economic Factors in the Production of Electrolytic Zinc." He pointed out first, that "the electric power must be convenient to the ore supply, or as the ore moves toward the power it must also move toward the metal market. Northwestern power is favorably located with reference to its ore bodies, and Mississippi Valley power favorably located with reference to metal market. In neither case will transportation charges accrue to a too great or unredeemed extent." Mr. Hall thought that the retort method of treating rich and pure concentrates, such as the Joplin ores, has nothing to fear from electrolytic processes. The latter are chiefly desirable in the treatment of the complex intimate mixtures of zinc, lead, iron, copper and silver minerals so often encountered in the Rocky Mountains. The adaptability in this case is not alone the actual cost of reduction of the zinc itself, but also the relative values of the subsidiary metals recovered, as compared with the results of retort smelting. "The one requirement for successful electrolysis of zinc is zinc sulphate and zinc sulphate only." Contrary to general belief, the solution of iron is not difficult to circumvent, considerable copper, however, will be removed from its rightful place in the residue. The conditions which produce so-called insoluble zinc ferrite in the roasting process are fortunately not necessarily present in a leach-roast; such factors are high temperature, long time, and fineness of ore. The author briefly points out that interfering elements may be removed by putting a zinc fume into solution, the lead and silver content in this case being insoluble, compact and easily washed zinc-free. Self-fluxing complex ores can be charged in a blast furnace and the slag losses in zinc are only of the same order as the summation of losses in the various steps in the other processes.

In the discussion of Mr. Hall's paper, LAWRENCE ADDICKS mentioned the fact that while the high grade 60 per cent zinc concentrate produced in Joplin was material par excellence for the retort, still a 25 to 30 per cent concentrate might be made from the chats and

tailings which would be very good material for an electrolytic zinc plant. DR. J. W. RICHARDS thought that since the retort smelting of zinc had improved perhaps 10 per cent in the last hundred years, while the electrolytic process had improved 100 per cent in the past five years, it was still too early to define the economic boundaries of the latter process. It seemed to him most important to determine how close to the end point the deposition can be carried, and how high the acidity of the solution can go. The chairman confirmed the author's statement that absolute purity in the electrolyte was the prime consideration.

In presenting his valuable paper on "Palmerton Zinc Refractories," Mr. C. P. FISKE said that the cost question in a pottery could be met in two ways, first by reducing the cost of the vessel, or second, by lengthening the service. The first method involves the reduction of labor charges, which has been effected to such an extent that seven men are enabled by the use of proper machinery to make 320 vessels per shift. He has tried to balance the cost of labor against the cost of operating additional automatic machinery, but was prepared to further reduce the men required if shortage of help demanded it. Involved in both methods of decreasing cost of vessels was the experimentation on retort-making materials, such as bond clay, calcined flint, and pulverized coke, the use of the latter, however, he regarded as of doubtful advantage. Pottery experiments, in general, are most difficult because they take a long time to complete, are liable to involve large losses, and the greatest care and supervision is essential. Therefore some method for determining quickly and surely the availability of any clay for a given duty is most desirable. In this connection Mr. Fiske regards the tensile test of air dried clay the most important and useful yet devised.

EXCURSION THROUGH THE MIAMI ZINC DISTRICT

Friday morning the travelers awoke in their berths and thought for a moment that they were aboard ship. The rolling and pitching of the cars was explained, however, by the fact that the rails over which we were proceeding had barely been laid, and that the roadbed was quite innocent of surfacing. Thus one is early introduced to the "newness" of the district. Mills and towns are springing up on every side, towns which jump at you out of a Bret Harte story book, towns where they have not yet had time to put in a culvert and fill a deep gulley crossing the main (and only) street. Breakfast was served in a large tent on top of Blue Mound, just over the line in Kansas, and from which an inclusive panorama of the district was obtained. After a few dances by some real American Indians, the party motored through the district, stopping at various mills and arriving at Miami for lunch, when the train left for Tulsa, where the large and orderly Cosden refinery was inspected during the late afternoon. The Tulsa committee entertained the visitors and guests at a very enjoyable banquet at Hotel Tulsa, following which a session on Petroleum was presided over by DAVID WHITE.

ORE-DRESSING PRACTICE

The ore-dressing practice in Joplin invites criticism from the visiting engineer. He is immediately struck with the multiplicity of small operating properties, and

reports of tailings dumps holding from 2 per cent zinc upwards. The local operator, however, maintains that his practice fits his conditions. That is to say, practically all mining is done by small operators under ten-year leases from the owner of the ground, who collects a royalty of from 10 to 20 per cent on the receipts from sales of concentrates. These leases ordinarily cover only forty acres of ground, often less, while the life of the mine is from six months to six years. The district as a whole seems to have had the benefit of little technical skill, and the whole object is to get out the rich dirt, make a clean, high-grade, coarse concentrate, and throw the rest away. Such small scale operation naturally militates against elaborate investigations or recoveries of fine concentrates or other refinements. The mills are uniformly built by millwrights, from the scantiest of plans, and of lumber and materials carried in stock or made locally. Consequently a new mill is ordinarily a copy of an older one, while innovations are short-lived owing to "the strong retrograde impulse which is so highly characteristic of the district."

All this explains conditions, but no reasons have yet been advanced why three mills operating within 100 yards of each other, each working one shift, could not consolidate their output and work one mill continuously. Or, taking a larger view, why a large block of ground could not be acquired, systematically developed and mined on a large scale, and more than 60 per cent of the zinc recovered. The newcomers evidently quickly acquire the local viewpoint, however. One operator was speaking of his seven-acre lease, and was asked why he did not acquire some of the adjoining area, and the reply was, "Oh, these seven acres will keep me busy for a while."

Mr. CLARENCE A. WRIGHT presented a discussion of the ore-dressing practice in Joplin which may here be abstracted. The average content of the ores mined is very low, the concentrate is very high grade, and the ratio of concentration is unusually high. The ore, or "dirt" as it is termed, is sometimes hand-picked, and broken to pass a 5-in. grizzly and then fed through a jaw crusher set at 2 in. The discharge is run directly to a set of rolls crushing to about $\frac{1}{2}$ in., elevated, screened, and sent to the roughing jigs. The most common type of jig is known as the Cooley jig. It is of the fixed-sieve type; the number and size of the compartments depending upon the size and character of feed.

In general, a system of "roughing" and "cleaning" is followed in which the feed is given a preliminary cleaning that eliminates the greater proportion of waste material on one or two "rougher" jigs and the enriched product, which will assay anywhere from 10 to 25 per cent zinc, is cleaned on a "cleaner" jig for the final treatment, bringing the zinc tenor up to 50 to 60 per cent. The "chats" or included mineral particles from both the rougher and cleaner jigs, which together assay 4 to 8 per cent zinc, are recrushed and either returned to rougher-jig feed or treated separately in a "chat" jig. The tailings from the rougher jig are usually dewatered by means of a dewatering trommel having $1\frac{1}{2}$ -mm. to 2-mm. openings while they pass over the outside of the trommel as it slowly revolves. The undersize from this dewatering screen flows to the settling tanks and the oversize to the tailings elevator as waste. The overflow from the tailing end of the cleaner jig,

and other jigs if used, also passes to the settling tanks.

During the past few years the use of tables has become general in the district, and nearly all mills contain from three to ten, the small number being due to the small tonnage of the mills and the minimum amount of fines produced. The feed, or "sludge," comes chiefly from the dewatering boxes at the end of the jigs, through a V-box with a continuous discharge and trommel. The usual practice makes clean lead and clean zinc concentrates; the intermediate material is returned to the feed, together with the middlings.

Flotation of the fines is in use at a few places. Tests by the Bureau of Mines showed that it is fairly easy to float the sphalerite by using warm solutions and about one pound per ton of any suitable wood or coal distillate, and that acidity separates the froth and tailing quickly. The present mill practice is however so firmly fixed that it will be difficult to convince operators of the desirability of adopting flotation extensively.

Mr. H. B. PULSIFER contrasted the operation of an old mill called the "Bohemian Girl," which was removed after three years' work, and the "Media" of about the same size jig-room but of three times the capacity (75 tons per hour). A flow-sheet of the Media is reproduced herewith. This mill has recovered about 2 per cent of the dirt as zinc, producing a 60 per cent zinc concentrate. The boiler plant and steam-engine drive has always been the main source of power in the district, and is unrivaled in low operating cost and reliability. The Media mill itself was constructed during the summer of 1915 at a cost of about \$60,000, and paid for itself in four months' operation. It has continuously ground 1200 tons in 20 hours in its single jig room, the capacity being limited more by mining than mill speed. A large tailing pond was constructed at considerable expense, but the output was allowed to encroach so that the pond capacity vanished in a few months. The customary "dummy" elevator became

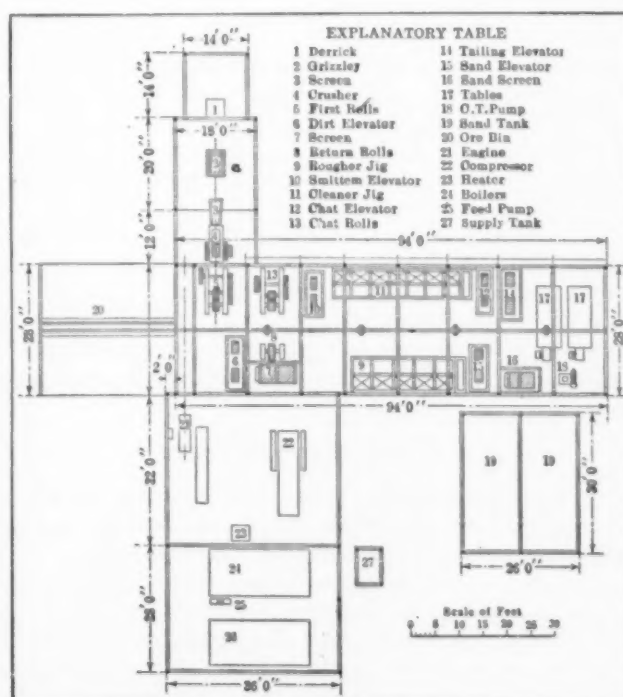


FIG. 1—FLOOR PLAN OF BOHEMIAN GIRL MILL

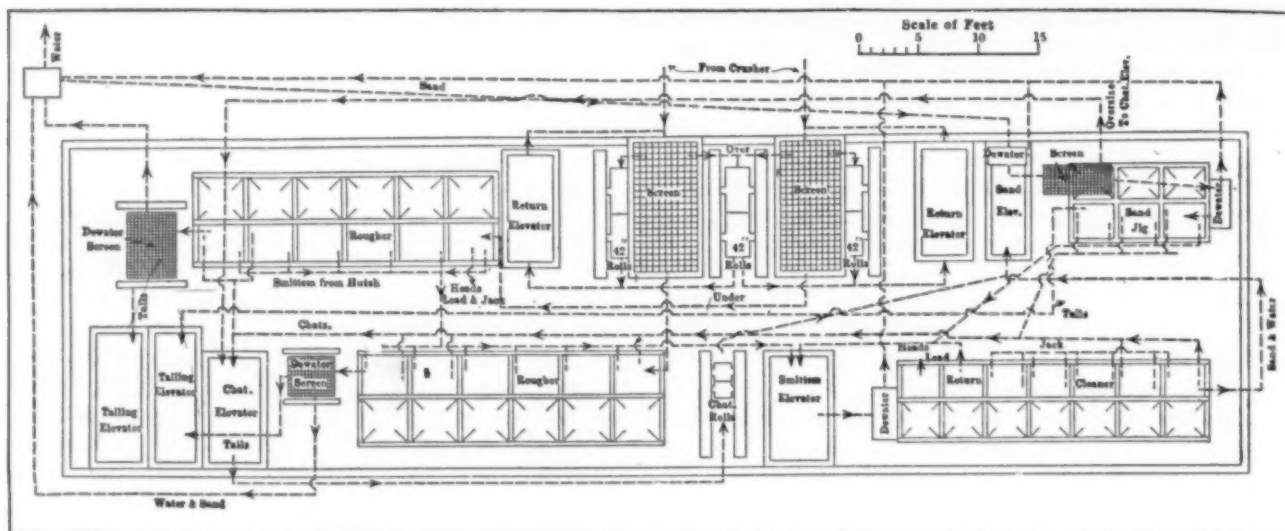


FIG. 2—FLOW SHEET OF MEDIA MILL

necessary. The greatest disadvantage is the undue crowding of shafting, belts, spouts and pipes in the jig room.

"The best features of the ore dressing may be enumerated:

"1. Main tonnage fall direct from hopper to tailing elevator; only oversize is re-elevated. Bad turns in main stream nearly absent.

"2. Splendid balance of unit capacity; no one unit crowded or choked while others are running light. If any capacity weakness develops it will probably be in the cleaner, chat-regrinding or sand units rather than in main tonnage units.

"3. The cleaner is of unusual size, only a few of this size ever having been built in the district.

"4. Ample facilities for dewatering sands and a sand jig in the main mill to treat cleaner sand and ground chats (settled rougher sand can also come back to this jig) relieves the roughers.

"5. The sand plant is entirely separate from the jig room, as is now fairly customary in the district. It has an equipment carefully selected and capable of excellent work.

"6. Mill water is elevated no higher than necessary; a second small pump supplies the high line to the crushers.

"7. The main tonnage flow is through twin units; this arrangement is happily combined with large units on the enriched segregate. Both streams being in the closest possible proximity, elevator fronts being open and nearly every unit being in full view, minimum attendance is required and instant response to mishap is possible."

OKLAHOMA ZINC SMELTERS

A large percentage of the Joplin-Miami "jack" is shipped into the Oklahoma gas fields, there being 78,672 retorts installed in fourteen different plants. The main impressions the casual visitor obtains from these plants is of their very flimsy buildings, their lack of labor-saving machinery, and the excessive heat losses through their furnace walls. Many of the plants are "war-brides," pure and simple, built to operate on high-price ore, and now in large measure cold. Quick and

cheap construction was therefore the first consideration, the buildings being mostly of corrugated iron directly on wooden posts and girts. The furnaces themselves seem to be merely fire-brick screens to protect the buckstays. The usual straight line (Ropp) roaster is fired with a gas flame at every door. The smoke from these roasters is singularly free from visible dust, when working on ordinary concentrate. Flotation products are much more difficult to handle, both to dry and to roast. The size is of small advantage even in the retort, owing to the extreme difficulty of getting them thoroughly and uniformly mixed with the rest of the charge and properly moistened.

The retort furnaces themselves are set on the general yard level, a tunnel for residue cars being built directly underneath. Since cheap natural gas is used, no recuperators are constructed. There is little of novelty in the retort practice in this field—the rapid expansion of the furnace capacity has involved an acute shortage in furnacemen, and under these conditions few innovations are likely.

The furnace operator defends his practice by pointing out that substantial construction is impossible in a region depending upon a short-lived gas supply. This same gas supply, however, might be extended almost indefinitely by proper development and conservation. Again, mechanical handling of materials is not an economic possibility when such small quantities of materials are to be handled—perhaps 150 tons of concentrates daily at the average plant. It does seem, however, that locomotive cranes could supplant the laborer and his shovel in rehandling large quantities of stockpiled materials.

Globe-Miami Copper Strike Settled

The strike in the Globe-Miami copper district of Arizona is settled. The President's mediation commission has succeeded in working out a plan of adjustment which has been accepted by the managers of the Old Dominion, Miami, Inspiration, and the International Smelter, the controlling mines; President Moyer, of the International Union of Mine, Mill and Smelter Workers, and the local unions which are out on strike. This means the early resumption of copper production.

The Western Metallurgical Field

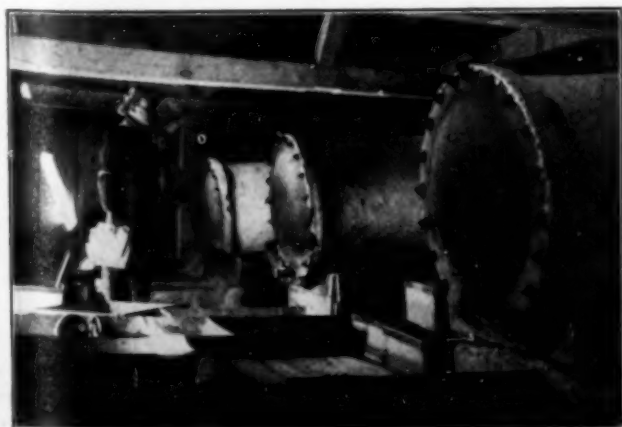
New Source of Sulphur in Colorado

A new source of sulphur is being made available to the Western market as a result of a bond and lease recently taken by Mr. Frank Bulkley of Denver, Col., on the property of the Colorado Sulphur Co., near Creede. The mineral deposit lies about 20 miles from Creede at the head of Sulphur Creek, a tributary of Trout Creek, which, in turn, flows into the Rio Grande. It was discovered by prospectors twenty or more years ago and was acquired in 1901 by the American Sulphur Co. A considerable sum of money was spent by this company before discovering that the deposit was on State school land, and therefore unpatentable. Litigation ensued as a result of an attempt by another party to secure a lease, but in 1906 the courts decided that the American Sulphur Co. was duly entitled to lease the land. A sub-lease was then granted to the Colorado Sulphur Co., which subsequently purchased the land from the State of Colorado.

Altogether about \$100,000 has been spent on the development and equipment of the property. Considerable underground work has been done, including exploratory work by diamond drills. A small refinery was erected comprising three retorts having a capacity of from 5 to 10 tons refined sulphur per day, depending on the grade of the ore. As shown in the accompanying view, the retorts are simple cast-iron cylinders laid at a slight inclination, so that the molten sulphur may be tapped from the lower end.

An examination of the property reveals the existence of about 30,000 tons of ore within a certain area, which will average 50 per cent sulphur. Samples of 100 lb. each taken in the usual approved manner from fourteen exposures of ore gave assays ranging from 41 per cent to 65 per cent sulphur, with an arithmetical average of 57.7 per cent.

The refining process is simple. Ore is loaded into small perforated-bottom cars which have been previously lined with burlap. These cars are then run into the retorts, and after the heads are bolted on, steam is turned in. The sulphur melts and runs through the burlap, while the unmelted gangue remains in the cars. Liquation thus proceeds for about an hour, after which the steam is turned off, the cars taken out and discharged. The melted sulphur is run out into pans and cooled, after which it is crushed and ground as required for market. The product is practically pure sulphur,



RETORT AND SULPHUR PANS

analyzing over 99.5 per cent pure in carload lots. No arsenic, selenium, tellurium or other deleterious elements are present.

Operations are now proceeding in a small way until next spring, when the refinery will be enlarged and motor trucks will be used for transportation of the product.

Zinc Production in Missouri

At the present time \$75 "ore" means curtailment in Joplin production. The casual observer might express surprise that the present price of zinc—somewhat over 8 cents—would not bring out the maximum quantity of that metal. The cost of labor, but more especially of supplies, has increased so largely that the total cost of mining and milling in the larger, more economical mines has increased from \$1.05 in 1914 to \$1.32 in 1916, and possibly \$1.50 to-day. Present costs in the Miami (Oklahoma) district are close to \$2 per ton.

In order to translate these mining costs into a figure which may be comparable with the price the miners are receiving for their "ore" or concentrates, one must recollect the excessively large concentration ratio ruling in Joplin. This ratio is becoming smaller all the time; thus 3.14 tons of concentrate were produced from 100 tons of "dirt" in 1914; 2.70 in 1915, 2.56 in 1916, and possibly 2.45 now. Dividing the cost of mining and milling 100 tons of "dirt" by these respective figures, it will be apparent how the cost per ton of concentrates has jumped from \$34 in 1914 to \$61 to-day. Now if a royalty of from 10 to 15 per cent be added to these figures, even the more modern producers of low-grade dirt will have a hard time to continue on a \$75 basis, while many of the smaller operators have already succumbed. While the Miami district costs are higher, the zinc content of the veins is also much better, so that concentrates can easily be produced at that place for \$50 a ton. Under such circumstances the exodus of operators from Joplin, Webb City and Cartersville into the boom towns about Picher, and the dismantlement of many mills for re-erection in Oklahoma, is not surprising.

Many hundreds of retorts in Oklahoma are cold. If a ton of concentrates will produce 1000 lb. of spelter, at say 8¼ cents, the smelters will receive \$82.50 for their metal. Transportation and selling of ore and metal costs in the neighborhood of \$5 per ton, while smelting costs are perhaps \$15. Subtracting \$20 from the price of the metal means that a smelting company cannot make a great deal of money at the present price of concentrates—in fact, many have given up the attempt.

The slump in spelter is doubtless due to the high price of galvanized products. This industry normally absorbs well over half the entire production of zinc. What with the extraordinary price of zinc early in the war, and the more extraordinary price of the iron sheets and wire forming the base of galvanized articles, the price of this class of goods has been put so high that the ultimate consumer either does without or takes a substitute—purchases galvanized fencing and corrugated sheets only as a last resort, perhaps after he has sold some of his potatoes or wheat. The effect of a stagnating market for galvanized ware on "war-bride" zinc retort capacity (doubled since the war) is very apparent.

American Iron and Steel Institute

The thirteenth general meeting of the American Iron and Steel Institute, held in Cincinnati, October 26-27, 1917, at the Hotel Sinton, was marked by the remarkable spirit of all the members for co-operation with the government, which was brought to a fitting climax when, at the request of Judge Gary, all present rose and pledged themselves to do their utmost for the service of their country.

On Friday, the morning and afternoon sessions were given up to the reading and discussion of the papers, and in the evening a banquet was held at the hotel, after which informal speeches were made by Mr. Charles P. Taft, Mr. George Verity, Captain R. W. Hunt, Mr. C. W. Howard, Mr. C. M. Schwab, Mr. J. A. Farrell and others, all of them dealing with the relation of the steel industry to the war.

Saturday was given over to visits to the various points of interest around Cincinnati.

The morning session on Friday was opened with the Presidential Address by Judge GARY, a remarkable speech in many ways, in which he brought out with great force the enormous burden which the iron and steel industry is called upon to bear.

After this speech Judge Gary called upon several members of the audience for informal discussion.

Colonel LAMBERT said that after hearing the speech

there was not much to say except that we indorse every word of it, and that we will do our full duty.

Mr. HOWARD of St. Louis said that we should take the message to heart deeply, and remember all service possible, showing the way to the world.

Mr. FARRELL, president of the United States Steel Corporation, stated that the war had brought changes in all industry, particularly the iron and steel industry. He said that it was an economic war, and that we must not only send men to the front, but we must also produce the necessary materials, etc. He also said that we all must co-operate, as in the end the winning of the war would depend on the United States, and particularly on the iron and steel industry.

Mr. SCHWAB, president of the Bethlehem Steel Company, said that he welcomed the opportunity to praise the president's address. In his own plant he was employing 80,000 men and had \$600,000,000 worth of contracts on the books, of which he was glad to say over 90 per cent were for the government. He called the institute's attention to the remarkable ability and diplomacy with which Judge Gary had conducted his dealings with the Council of National Defense at Washington, always considering the best interest of the country and the steel industry as a whole, at many times to the disadvantage of the corporation. A report of the technical papers will be given in our next issue.

Helping to Win the War by Stimulating Liberty Bond Sales



Liberty Loan meeting of employees of McGraw-Hill Publishing Company, Inc., at which there was unfurled a service flag with 42 stars, showing that 42 members of the company have entered military service. Since the meeting 4 stars have been added

How Do the Warring Nations Obtain Their Nitrogen Supply?*

By S. Nauckhoff

The great chemist Liebig once uttered the words "without phosphorus, no mind," and this expression, in a somewhat altered form, can truly be applied to an element closely related to phosphorus, namely nitrogen, in that we can say "without nitrogen, no war." To such an extent was and is war dependent upon this, in itself, so simple and common non-metal, that we would almost wish that in an instant it could be excluded from the list of the chemical elements. But as long as the human brain has access to phosphorus it may well be assumed that substitutes for nitrogen would quickly be invented and put at the disposal of the militarists.

A discussion of the nitrogen question and its importance from the military point of view, which at the present time is of considerable interest, can be found in Ostwald's "Abrundungen und Vorträge," written during the summer of 1903. Ostwald says there: "If today a war should break out between two great powers, of which one were in a position to prevent the export of saltpeter from the few ports of Chile, it would thereby make it impossible for the enemy to continue the war longer than its ammunition supply should last. At present this condition is not very serious for Germany, as on account of the requirements for agriculture and chemical industries the stock of saltpeter in the country is so large that even the considerable military requirements could be met. This, of course, holds true only until the deposits in Chile approach their exhaustion."

Whether Ostwald when he wrote this had the relation between Germany and England in mind does not

*Paper presented before the Swedish Technological Society, Section of Chemistry and Mining, Feb. 8, 1917.—Translated from *Teknisk Tidskrift* for February-March, 1917.

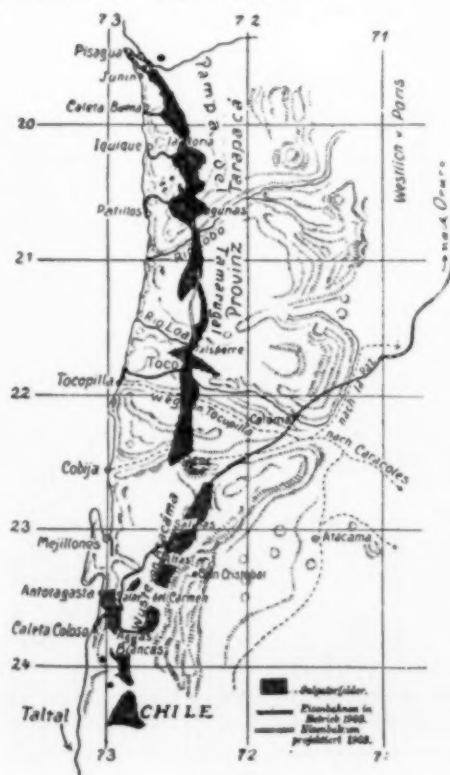


FIG. 1.

appear from his argument, but it does not seem to be unlikely. To draw a conclusion from the statistics as to Germany's saltpeter stock at the beginning of the war is not possible, although Washburn¹ estimates it at approximately 660 thousand tons. This, therefore, corresponded to what Ostwald termed "the considerable military requirements," and was certainly very much greater than the stock of England. Furthermore,

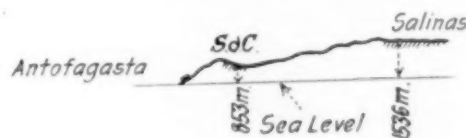


FIG. 2.

the Germans by the capture of Antwerp are said to have obtained about 200,000 tons of saltpeter. One can, therefore readily understand that the Germans at the beginning of the war, regardless of their inferiority at sea, risked the attempt to blockade the Chilean ports with their cruisers; and it may not be considered impossible that a future operating field for the German submarines will be the coast of Chile.

The Chilean saltpeter industry is in many respects very interesting and a short résumé of the same will, therefore, first be given.

As seen from Fig. 1, the most important saltpeter deposits are located in a belt parallel with the coast, reaching from 19½ to 24½ south latitude and entirely within the rainless and desert regions of the coast. The elevation above sea level of part of the saltpeter fields is considerable, reaching 1550 meters, as seen

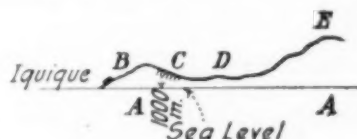


FIG. 3.

from Figs. 2 and 3, showing the Antofagasta district in the south and the Iquique district in the north. The nitrate-bearing earth or "caliche" which is found a few feet below the surface has a thickness varying from a few inches up to 12 feet, the average being approximately two feet. The caliche rests on a bottom which consists of a soft earth, known as the "coba" and is covered by a compact over-burden of earth, known as the "costra." The saltpeter content varies considerably, for example, from 25-40 per cent in the Atacama district and 30-50 per cent in the Tarapaca district.

Concerning the formation of the saltpeter deposits the opinion among geologists differ. The theory of Nöller seems, however, to be the most likely. He declares that their origin is due to the collection of enormous quantities of sea-weed, which together with the salt from the sea water formed the nitrate during their decomposition. A proof of this is the large iodine content of Chile saltpeter.

In this connection it may be sufficient to refer to Figs. 4, 5, 7 and 8, showing how the saltpeter is recovered from the caliche.

To give an idea of how inefficient the saltpeter ex-

¹Met. & Chem. Eng., Apr. 15, 1916, p. 419.



FIG. 4. MINING OF CALICHE AFTER BLASTING THE COSTRA.

traction is in the Chilean factories, it may be mentioned that when working a 35 per cent caliche, the following losses, which for a European chemist appear amazingly large, are figured:

	Per cent.
In transport from the saltpeter fields to the refining works (Oficinas).....	7.0
In crushing and solution of the caliche.....	2.0
In the residue (Ripio).....	14.3
In drying and in end solutions	8.7
Total	32.0

The finished product, the fertilizer saltpeter, has a NaNO_3 content of about 95-96 per cent, corresponding to about 15 per cent N, and contains ordinarily from 1-1.5 per cent NaCl besides smaller amounts of sulphates, perchlorates, iodines, etc.

The moisture content generally is between 2 and 3 per cent.

Besides the above, there is in the market a "refined" saltpeter with a standard content of 96-97 per cent NaNO_3 and less than 1 per cent NaCl. This is mainly used for the manufacture of nitric acid and for other chemical purposes.

Coming then to the question of the saltpeter trade, I will first endeavor to illustrate by diagram, Fig. 6 showing Chile's saltpeter production for 1870-1916, how the same has expanded during the last 35 years. The scale to the left in the diagram gives the quantity of saltpeter in thousand tons, and the scale to the right the



FIG. 5. DUMPING THE CALICHE INTO THE SILOS ABOVE THE CRUSHERS.

corresponding amount of nitrogen, also in thousands of tons.

As it is at once apparent what an enormous increase in production has taken place during this comparatively short period, the question naturally arises: "How long can the Chile saltpeter deposits last?"

To find an even approximately correct answer to this is, however, impossible. It appears almost that it is with the Chilean saltpeter deposits as with the Swedish iron ore deposits; they grow with every new estimate and investigation.

While about 1860 the available deposit of saltpeter was estimated to be 63 million tons, this figure was twenty years later increased to 178 million tons. In 1888 the Chilean saltpeter officials, however, declared that the deposits would last only for 25 years longer, i.e., would be exhausted by 1913, although in 1900 they declared that the time limit could then be extended to 1940. In 1907 it was found that the deposits would last to the year 2032, and finally the Chilean Government announced in 1909 that at least 340 million tons could yet be economically mined, which, at a yearly production of 2.5 million tons, would correspond to a period of 136 years. In Europe, however, no faith is had in these Chilean reports, and it is generally believed that these high estimates have been made only to enable Chile to maintain its credit in the European and American money markets. That the saltpeter industry is of the greatest importance to the Chile Government is readily understood from the fact that the export duty of saltpeter, which is not less than 28 pence per Spanish cwt. (46 kg.), corresponding to around 25 per cent of the saltpeter value in a Chilean port, covers approximately 40 per cent of the Government's total expenses.

European authorities figure now that the Chilean deposits will last not more than 50 to 60 years, and this is also the reason why preparations are beginning to be

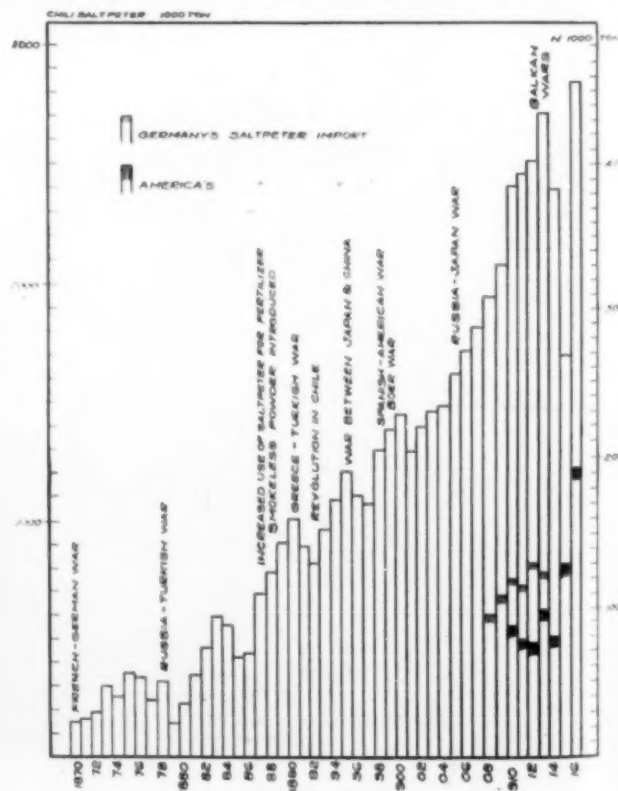


FIG. 6.

made in Europe to make it independent of the Chile salt-peter.

A closer study of the diagram shows, furthermore, several other interesting facts, but in this connection we are mainly interested in the effect of the war on the salt-peter consumption. Nearly every war is marked by a distinct increase in the production, but compared with the present conditions the nitrogen consumption of the wars of the past 30 years have been mere trifles to this war's enormous requirements. The incomparably greatest increase in salt-peter consumption during the past 25 years refers, however, to the increase in its use for fertilizer purposes.

By studying the salt-peter production in the diagram for the past 4 years, it is at once apparent what violent fluctuations the present war has caused in the salt-peter trade. At the beginning of the war the salt-peter export to Europe stopped almost entirely, and work was discontinued in more than two-thirds of the approximately 135 refineries which were in operation at that time. At the same time the salt-peter stock in Chile increased from about 500,000 tons in January, 1914, to about 1,100,000 tons in January, 1915. During the first half of the year 1915 the production dropped further, when, due to the increased ammunition production in America, it began to rise rapidly until during 1916 it reached the record figure of 2,878,000 tons. At that time 116 refineries were working at full capacity. Of the above, not less than 1,200,000 tons was taken by America against about 500,000 tons before the war.

The diagram further shows Germany's salt-peter import during 1908-1911, according to official German statistics and also America's import during the past 7 years. From this it follows that Germany's total normal requirements of salt-peter for agricultural and industrial purposes have amounted to about 800,000 tons, corresponding to about 120,000 tons of nitrogen.

At the same time I can mention that the German ammonium sulphate production during 1913 amounted to 550,000 tons, corresponding to 110,000 tons nitrogen, this, however, not including the ammonium sulphate produced by the Haber process. Germany's total nitrogen requirements during 1913 may, therefore, have been about 228,000 tons. Of this, according to Kochmann (*Deutscher Salpeter* 1913), 146,000 tons of nitrogen was used for fertilizer purposes. The balance, 82,000 tons, can, therefore, be assumed to have been used in

the German chemical industry, mainly for dyes and explosives.

Before leaving the Chile salt-peter I will endeavor to show with a few figures how the prices for the same are made up.

At a normal price of about 185 marks (or shillings) per ton, f. o. b. a port in the North Sea, approximately 55 mks. (s.) can be figured as the cost of production, about 50 mks. (s.) as export duty, and about 17.5 mks. (s.) for transportation. The balance, 62.5 mks. (s.), therefore, covers the commercial expenses and the profit.

At present when salt-peter is quoted at £20 in Liverpool, about 70 to 80s. goes to cost of production, 50s. to export duty and 150 to 160s. to freight. The balance, 110 to 130s., covers commercial expenses and profit.

AMMONIUM SULPHATE

A comparison between diagrams Fig. 9 and Fig. 10 illustrates plainly that, of the natural nitrogen sources, Chile salt-peter has without question been of the greatest significance. How the importance of the ammonium sulphate constantly increases appears from the diagram in Fig. 10, which shows the production of ammonium sulphate in England and Germany during the past 25 years. England, which earlier controlled the ammonium sulphate market, had in 1910 to concede this place to Germany. Germany and England each produced at that time somewhat more than one-third of the entire world production. During the last four years England's production of ammonium sulphate has been nearly constant at a little over 400,000 tons (or 82,000 tons nitrogen) while the production in Germany has increased rapidly. Figures for the years since the war broke out are, however, not available, but with a knowledge of the enormous increase in the coke-oven industry in Germany, which is said to have more than doubled, we may not be far from correct if we estimate the production in this manner to approximately 150 to 200 thousand tons of nitrogen. In America, also, the coke-oven industry has expanded considerably and the recovery of by-products has at the same time reached constantly greater proportions, this quite naturally in order to obtain raw materials for the enormously increased manufacture of ammunition. According to the *Chemical Trade Journal*, the ammonium sulphate production in America amounted in 1916 to 325,000 tons, an increase over 1915 of not less than 105,000 tons. If we

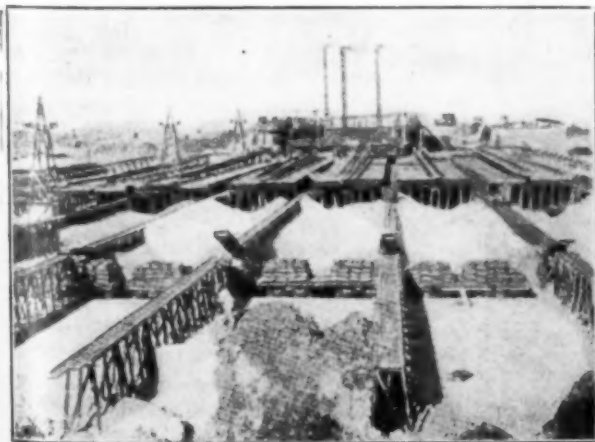


FIG. 7. SALT-PETER FACTORY, OFICINAS, AT SAN JOSÉ, IN THE TARAPACA DISTRICT.



FIG. 8. SALT-PETER BEING LOADED FROM THE CRYSTALLIZATION TANKS INTO CARS TO BE CONVEYED TO STORAGE.

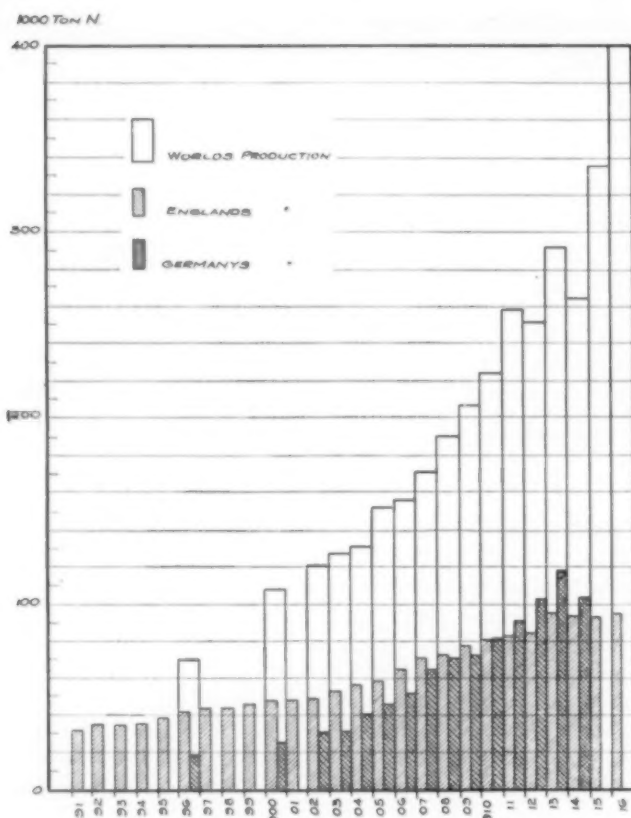


FIG. 9. GRAPHIC REPRESENTATION OF THE PRODUCTION OF AMMONIUM SULPHATE DURING THE 25-YEAR PERIOD 1891-1916.

further consider that a considerable increase is likely to have taken place in other countries, it may be safe to estimate the world's production of ammonium sulphate during 1916 at more than 1.6 million tons or more than 330 thousand tons of nitrogen. This proves that ammonium sulphate, as a source of nitrogen, has reached nearly the same importance as Chile saltpeter. With a closer comparison, however, one must consider that when fertilizers are concerned, the fertilizing value of ammonium nitrogen can be valued only at about 70-80 per cent of that of saltpeter nitrogen.

The above natural nitrogen sources, saltpeter and ammonium sulphate from coal have, however, been far from sufficient to fill the enormously increased demand, caused by the world war. Artificial nitrogen products also have come into use to a very great extent, and in this case the atmosphere has been relied upon to furnish the raw material.

ATMOSPHERIC NITROGEN

Fig. 10 is intended to represent the different methods for fixation of atmospheric nitrogen and their relation to each other. In general, these processes may be divided into two groups. First, those for producing saltpeter-nitrogen and, second, the processes for producing ammonia-nitrogen. The former methods are based on the combustion of the nitrogen in the air, at high temperatures, at the expense of the oxygen therein, and the nitric oxide which is obtained as a first product can then readily be converted to nitric acid and nitrates. The latter methods include both those according to which synthetic ammonia is produced directly from the nitrogen in the air and from free hydrogen, and those



FIG. 10. RELATION BETWEEN THE DIFFERENT METHODS OF ATMOSPHERIC NITROGEN FIXATION.

which necessitate a round-about way by means of other nitrogen combinations such as cyanamid, cyanides, nitrides, etc. The latter processes generally presuppose that the nitrogen in the air is separated from the oxygen, which nowadays is most readily done by liquefaction and fractionation of the air.

As the largest part of the nitrogen for ammunition manufacture is used in the form of nitric acid, it follows that the ammonia which is produced according to any of the above mentioned methods, or as a by-product in coke manufacture, must be converted into nitric acid, which is possible by the catalytic oxidation process.

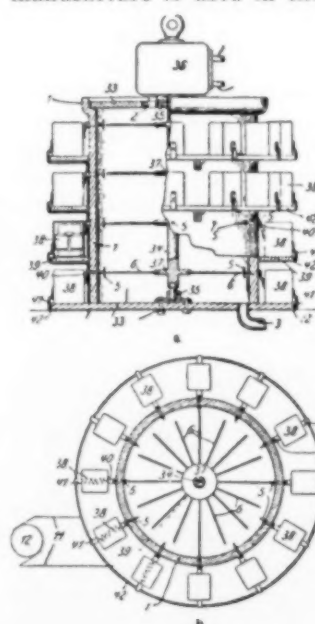


FIG. 11. BRADLEY AND LOVEJOY'S APPARATUS FOR ATMOSPHERIC NITROGEN PRODUCTION

COMBUSTION OF AIR BY ELECTRICITY

As everyone remembers, it attracted a good deal of attention, when in the beginning of this century it was announced that a process had been invented in America whereby it was possible to produce nitric acid from atmospheric air. Bradley and Lovejoy built a small factory at

Niagara Falls where extensive and very expensive experiments were conducted with an apparatus which they had designed. Their aim was to oxidize the nitrogen of the air by leading it through a large number of small electric arcs, formed between movable electrodes in the interior of the apparatus, Fig. 11. After years of trials and great expense the experiments had to be given up and it was with these results fresh in mind that many, a few years later, received the announcement of the Birkeland-Eyde experiments with considerable doubt. This process has, nevertheless, been the entering wedge in this field and the origin of a gigantic industry favored by our northern conditions.

As is well known, the combustion of the nitrogen in this furnace takes place in an electric arc formed between two copper electrodes, which by the action of a strong magnetic field is expanded to a circular disk of large dimensions, often over 2 meters in diameter, Fig.

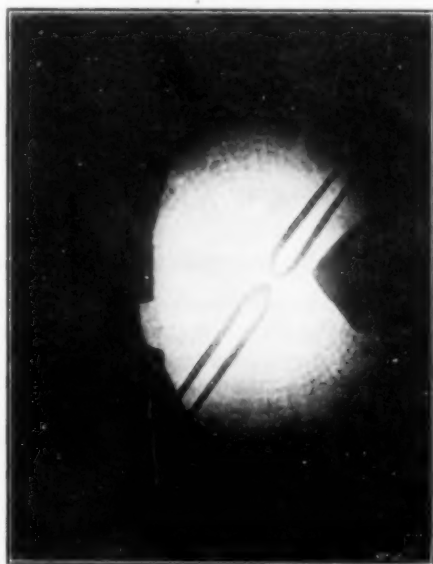


FIG. 12. THE ARC IN A BIRKELAND-EYDE FURNACE

12. The arc is produced by means of a high tension alternating current having a frequency of around 50 cycles. The larger furnaces, in which the arc has a diameter of about 2.5 meters, utilize up to 3500 kilowatts. An air current of approximately 2 cubic meters per minute is forced through the furnace, whereby the outgoing gas has an NO content of about 1.5 per cent. The gas leaves the furnaces with a temperature of 800-1000 deg. C., and is led through specially designed boilers, where it gives off the greater part of its heat and the temperature is reduced to 150-200 deg. The gases thereafter pass through aluminium coolers which further lower the temperature to a value which is suitable for the subsequent oxidation process. This oxidation of the nitric oxide with oxygen from the air takes place in large chambers of iron covered on the inside by acid-proof material. From these oxidation chambers the gases are led to a system of absorption towers, built of acid-proof granite, Fig. 15. A spray of water is sent through the last of these towers in the opposite direction to the entering gas and the weak acid, which is obtained here, is then successively led to the other towers, also in a direction opposite to the flow of the gas. The first tower gives in this way a nitric acid of up to 50 per cent concentration. For the final absorption, the gases which are

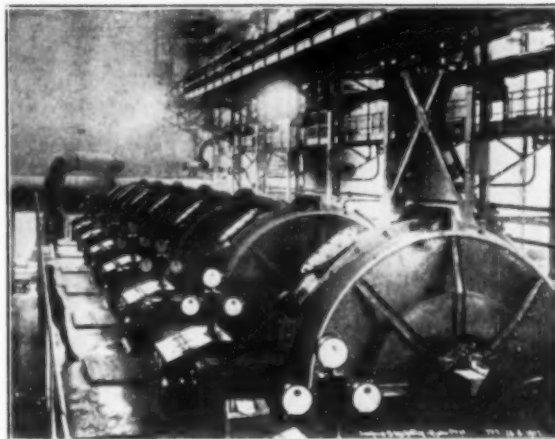


FIG. 13. BIRKELAND-EYDE FURNACE IN THE FACTORY AT RJUKAN IN NORWAY. CAPACITY OF EACH UNIT 3500 KW.

not absorbed in the water are led through an iron tower containing a soda solution, from which a solution of nitrate and nitrite is obtained. In this way up to 96 per cent of the oxidized nitrogen is recovered. From the nitrate-nitrite solution nitrate can be produced or, also, by letting the solution go to the first tower together with the strong nitric acid, the nitrite is decomposed and a nitrate solution obtained from which sodium nitrate of great purity can be produced.

With a 96 per cent NO absorption the Birkeland-Eyde process gives 550 kg. nitric acid per kilowatt-year of energy utilized in the furnace itself. A furnace of a capacity, as previously given (3500 kw.), produces therefore with continuous operation 1925 tons of nitric acid, corresponding to 420 tons of fixed nitrogen per year. Of this about 85 per cent is in the form of a nitric acid with a 40-50 per cent concentration and the balance, about 15 per cent, in the form of sodium nitrate. The operation of blowers, pumps and other auxiliary machinery require an additional energy consumption of about 7 per cent of the energy utilized in the furnace. Other losses (shut-down as well as concentration losses when an acid of high concentration is produced) can also be figured at 7 per cent, and the final result can therefore be taken as 425 kg. 96 per cent nitric acid = 91 kg. nitrogen, and 102 kg. 96 per cent sodium nitrate = 16 kg. nitrogen; total per kw. year, 107 kg. nitrogen, or approximately 80 kg. nitrogen per hp. year.

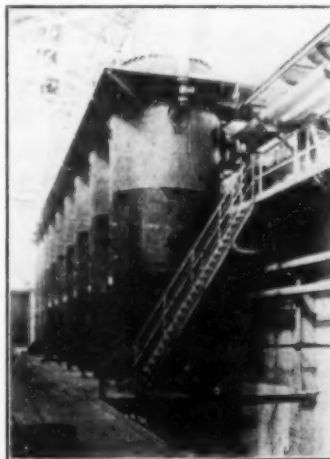


FIG. 14. STEAM BOILERS IN THE RJUKAN FACTORY, HEATED WITH THE GASES FROM THE ELECTRIC ARC FURNACES.

About the time when the Birkeland-Eyde process began to get a practical application in the factories at Notodden in Norway, the Badische Anilin und Soda-fabrik finished experimenting with a furnace design invented by Schönherr and based on a long drawn electric arc. This invention was acquired by the Norwegian Nitrogen Company, in which the Badische

Company had large financial interests, and part of the first large installation at Rjukan was built according to this system. The Schönherr furnace has the form of a long vertical tube, at both ends of which electrodes are applied. The arc has a length of from 5 to 7 meters. The air which is blown in tangentially at the lower end of the tube passes with a whirling movement around the arc and leaves the furnace at the upper end, where special cooling devices are provided to rapidly cool the gases. The Schönherr furnaces are built for much smaller capacities than the Birkeland-Eyde type. They utilize generally only from 500 to 1000 kilowatts, and the manufacture of a certain quantity of nitrogen compounds will, therefore, require four times as many furnace units of the latter type. With the Schönherr furnace a somewhat higher gas concentration can be reached than with the Birkeland-Eyde furnace, but the nitric acid exchange, figured per kilowatt year, remains practically the same.

Several other arc furnaces have been designed. Of these, however, only those of Pauling, v. Kock, and Moscicki have come to any practical use. The two former seem to be used to quite a considerable extent in Germany during the war, and one factory is working in Schweitz which utilizes the Moscicki method. Pauling and v. Kock furnaces are based on the horn-gap lightning arrester principle, i. e., the arc is formed between two electrodes similar to horn-gaps. Air is blown into the gap where the distance between the electrodes is smallest, the arc travelling upwards as the nitric oxide is formed. Moscicki produces an arc between two copper pipe electrodes, concentrically arranged. By putting this arc under the influence of a strong magnetic field, in which the lines of force pass at right angles to the electric discharge, he causes the arc to travel around. With a sufficiently high rotation the arc obtains the form of a circular disc and air is blown through this at a certain regulated rate.

THE EXPLOSION-COMBUSTION METHOD

A few words may also be said about a method closely related to the electric-air combustion or arc method, which, however, has not as yet come to any practical

use, but which offers various points of interest. This refers to the Hauser explosion-combustion process, which is based on the principle that in an explosion of a gas mixture containing air, part of the nitrogen of the air is oxidized. In a large experimental factory in Germany the method was carried out as follows: In explosion bombs, having a volume of from 200 to 300 liters, a mixture of from 200 to 300 liters, a mixture of coke-oven gas, air

and oxygen was compressed to a pressure of from 4 to 5 atmospheres, after which the mixture was exploded by an electric spark. The bombs are provided with regulating valves, which are manipulated so that the filling, exploding and blowing-out of the explosion gases can be repeated 50 to 60 times per minute. The gases have a NO content of 0.7-0.8 per cent and are consequently much weaker than the gas obtained in the electric arc furnaces. According to Döbelstein, about 190 gr. of HNO_3 was obtained for each cubic meter of gas of 4300 heat units. Based on a nitrogen price of 1300 mk. per ton in the form of lime nitrogen, Döbelstein figures that 2.4 pf. per cubic meter can be paid for the gas, while, if concentrated nitric acid with a nitrogen value of 1830 mk. per ton is manufactured, the gas can be paid for at 3.3 pf. per cubic meter; that is, it would be worth four times as much as if it was used for boiler fuel. It may not, therefore, be entirely impossible that the process can be developed as a paying industry in connection with the distillation of coal.

To work with the lean gases yielded by this process, offers, however, naturally many difficulties, and in Germany at present it appears to be preferable to use the coke-oven gases for motor drive for generating electric power for production of cyanamid or for the arc process.

TRANSFORMATION OF NITROGEN INTO AMMONIA

Several methods have been invented for fixing the nitrogen in the air in such a manner that it can readily be converted into ammonia-nitrogen. Neglecting the attempts which were made during the middle of last century to fix the nitrogen in the air in the form of cyanides, a method which, however, is again being given consideration as a possible solution of the nitrogen-fixation problem, it can be said that the cyanamid process by Frank and Caro has been the pioneer in the field. This method, which was originally worked for producing cyanide for gold extraction, soon changed its aspect. Without aiming at it, Frank and Caro had found a method, the main feature of which was its possibility of transforming the nitrogen in the air to ammonia. The method therefore became of the greatest importance for the fertilizer industry and this regardless of the fact that cyanamid in itself has not proved equal to the expectations of those who thought they saw in it an excellent fertilizing material.

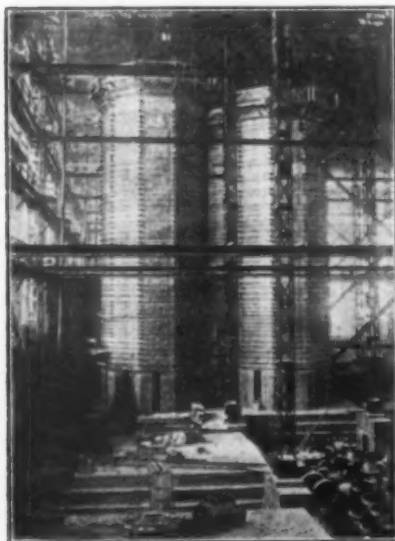


FIG. 15. ABSORPTION TOWERS OF ACID-PRO F GRANITE IN THE RJUKAN FACTORIES.

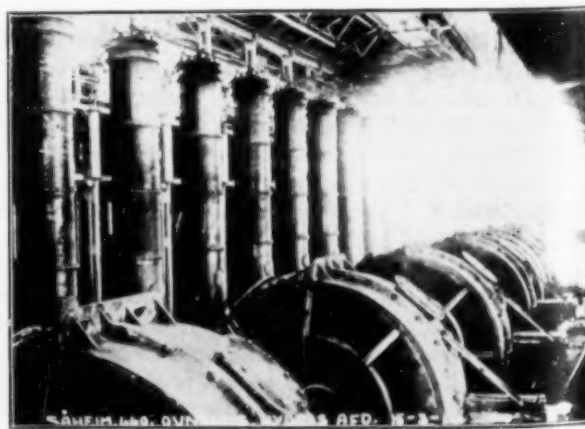


FIG. 16. SCHÖNHERR FURNACES IN THE RJUKAN FACTORY.

THE CYANAMID PROCESS

As is well known the Frank and Caro process is based on the property of carbide whereby it will absorb nitrogen at a high temperature, forming cyanamid according to the equation



This reaction takes place at such a high temperature, about 1000 deg. C. that great difficulties were encountered to begin with. By use of an activating agent, such as potassium chloride proposed by Polzenius or calcium fluoride by Carlsson, it has, however, been possible to reduce the nitrification temperature to 700-800 deg. C. The nitrification itself is done in furnaces of widely differing construction, both of the continuous and the intermittent type, with direct or electric heating. The nitrogen needed is produced either by leading air over incandescent copper or, as is now most common, by fractionation of liquid air according to the Linde or Claude processes.

Compared with the previously mentioned arc processes, the cyanamid process for nitrogen-fixation requires considerably less energy. Not less than 2 tons of 20 per cent lime-nitrogen can thus be produced per kilowatt-year, corresponding to 420 kg. nitrogen or approximately four times as much as with the Birkeland-Eyde method.

THE NITRIDE PROCESS

A clever method for fixation of the nitrogen in the air is the Serpek process for the production of aluminium nitride. Serpek discovered that if pure nitro-

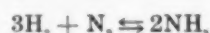
gen was permitted to act on aluminium ores or bauxite and carbon, at a temperature of from 1500-2000 deg. C., aluminium nitride, AlN , was formed, which can readily be transformed into ammonia and alumina. Rotating electric furnaces as shown in Fig. 17 are used for the process. The method therefore serves the double purpose of nitrogen-fixation and alumina recovery and it is on this assumption that its economical possibilities are based. Up to the present it has, however, not been possible to make the process a financial success, undoubtedly on account of the technical difficulties in connection with the high working temperatures which have yet to be overcome.

As to energy consumption, the Serpek process is superior to the previously described processes in that from 500 to 600 kg. nitrogen can be fixed per kilowatt-year and at the same time 2 tons of alumina be obtained. As mentioned, the difficulties of the process have as yet not been overcome, and it seems that the factories which were built in France and Norway have had to discontinue their operation.

Closely related to the previous methods for atmospheric-nitrogen fixation is one invented in Sweden by Lindblad and Yngström. Like the Serpek process it is a combination process and is based on the fact that an alkali ore mixed with coal and melted in an electric furnace possesses the ability to absorb nitrogen with the formation of cyanides. From the cyanide thus obtained, ammonia and potash are then produced. The nitrogen production according to this method is claimed to be about 100 kg. per kilowatt-year, consequently quite low, although the importance of the process lies in the fact that the alkali is simultaneously obtained.

THE SYNTHETIC AMMONIA PROCESS

We will now leave the indirect methods for converting the nitrogen into ammonia and proceed to the direct one, the Haber synthetic process, in which the technical development excels at present. The idea of uniting nitrogen and hydrogen under high temperatures and pressures in the presence of a catalyst is not new, as is among other things apparent from the following statement in Graham-Ottos's text book, published in 1881; "If hydrogen and nitrogen are mixed in the proportions in which they are contained in ammonia, no combination can be produced by means of pressure, heating or platinum catalyst." Several inventors have, however, since that time been able to prove that light electric discharges, or the action of catalysts, even so simple as the common metals, have produced ammonia in not inconsiderable quantities. In 1907 Nernst and Jost carried out a series of extensive experiments to determine the equilibrium in the system



and obtained thereby a confirmation of what they had previously predicted on the basis of theoretical conclusions; that is, that a higher pressure results in a quicker reaction and a higher ammonia concentration. With manganese as a catalyst, a temperature of 700 deg. C. and a pressure of 50 atmospheres, Nernst succeeded in reaching a concentration 0.9 volume per cent, but he still was very doubtful as to the ultimate success of any direct synthetic ammonia process. In this respect, the problem was therefore not new when Haber, with the assistance of Le Rossignol in 1907-1908

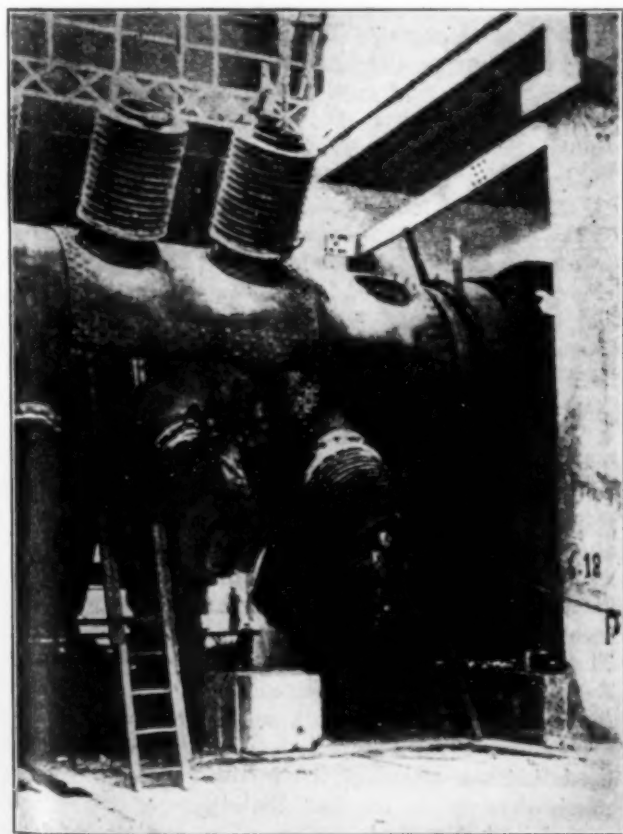


FIG. 17. SERPEK FURNACE FOR THE PRODUCTION OF ALUMINIUM NITRIDE. THE ILLUSTRATION SHOWS THAT PART OF THE FURNACE WHERE THE ELECTRODES ARE APPLIED.

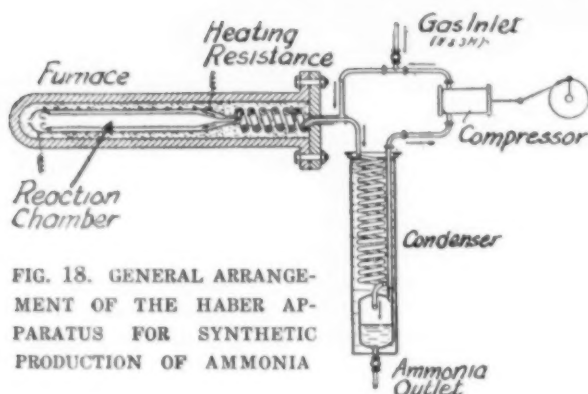


FIG. 18. GENERAL ARRANGEMENT OF THE HABER APPARATUS FOR SYNTHETIC PRODUCTION OF AMMONIA

took up the same. By a careful study of the equilibrium between nitrogen, hydrogen and ammonia at very high pressures, these inventors succeeded in finding the most favorable pressure and temperature relations for the formation of ammonia. Besides this they found that osmium as a catalyst had a great power to hasten the reaction and that thereby an NH_3 concentration of even up to 8 per cent could be reached. In their experiments to get the most suitable apparatus for their process the inventors were powerfully assisted by the Badische Anilin und Soda Fabrik and in this manner they succeeded in developing their process to a real commercial industry of great proportion.

The Haber apparatus, as far as it has appeared in the technical literature, is shown in Fig. 18, and concerning its description the reader is referred to Berthsen's paper before the International Congress of Applied Chemistry, in New York, 1912.²

On account of the scarcity and high price of osmium, the Badische company has especially investigated various catalysts to find one cheaper but at the same time equally as effective as osmium. In this manner a number of technically possible catalysts have been found. What is at present used in the actual manufacturing processes in Germany is, of course, a secret, but the general guess is that it consists of iron, produced and treated in a special way.

In 1910 the Badische company could consider the technical side of the synthetic ammonia problem solved, and proceeded to the building of the first large factory for this purpose at Oppau, near Frankfurt. This plant had in 1913 a capacity, according to certain reports of 30,000 tons, and, according to others, 60,000 tons of ammonia sulphate per year. It is also quite significant of the belief by the Badische company in the Haber process, that beginning with the operation of the Oppau plant they withdrew the greater part of the capital (about 20 million Mk.) which they, in connection with the other German dye manufacturers, had invested in the Norwegian salt-peter industry.

The raw materials for the Haber process are as mentioned, nitrogen and hydrogen. The nitrogen is produced

by distillation of liquid air at a reported cost of only 3 to 4 pf. per kg. The hydrogen is produced from water-gas according to the Linde-Frank-Caro scheme, in that steam is led over incandescent coke, after which the water-gas thus obtained is purified from carbonic acid by absorption in lime. By cooling with liquid air the nitrogen and carbon monoxide are brought into a liquid state and in this manner separated from the hydrogen. By fractionation of the nitrogen-carbon monoxide solution, part of the nitrogen required for the synthesis is obtained and also fuel gas in sufficient quantity not only for this process itself, but also for driving the liquid-air machines for the nitrogen production. A sketch of the apparatus which is used in this method of producing hydrogen is shown in Fig. 19. The cost for the hydrogen is given as only 9 to 11 pf. per cubic meter or about 1 Mk. per kg.

According to a method for hydrogen production, invented by Bergius, in which superheated steam is allowed to act on iron at a temperature of 300 deg. C., it is claimed that hydrogen can be produced still cheaper, namely, for 40 pf. per kg. If, on the other hand, the process could be combined with some electrolytic process where hydrogen was obtained as a by-product, it would be even still cheaper. The cost of synthetic ammonia production, according to Muhlert,³ is given in the following at different prices for hydrogen and nitrogen.

14 Kg. Nitrogen at 2 pf.	=	0.28 Mk.	at 3 pf.	=	0.42 Mk.
3 Kg. Hydrogen at 40 pf.	=	1.20 Mk.	at 100 pf.	=	3.00 Mk.
17 Kg. Ammonia	=	1.48 Mk.		=	3.42 Mk.
1 Kg. Ammonia	=	8.8 pf.		=	20 pf.
1 Kg. Nitrogen	=	10.6 pf.		=	24.4 pf.

The largest items in the cost of this process seem to be those covering the interest and amortization of the exceeding high first cost, and also the charges for repair and maintenance. It is claimed, however, with certainty, that ammonia can be produced by the Haber method at a considerably lower cost than with any other process in commercial operation.

The power consumption with the synthetic ammonia process is exceedingly small, so that the cost of power can almost be neglected in figuring the cost of production. Only about 0.5 kw.-hour is required per kg. ammonia, that is, not less than 10,000 kg. of nitrogen can be fixed per kilowatt-year.

OXIDATION OF AMMONIA

As before mentioned, incomparably the largest portion of the nitrogen required for ammunition purposes is used in the form of nitrates or nitric acid. All the above processes for nitrogen-fixation, which have ammonia as a final product, would, therefore, be of little value from a military point of view if no method existed for converting the ammonia into nitric acid. Thanks to the work of Ostwald, however, a comparatively simple and inexpensive method has been found for converting the ammonia and thereby also the free nitrogen in the air. For a long time it has been realized that the action of the fertilizers containing ammonia depends on the fact that the ammonia is converted into nitrates by means of an oxidation process in the soil. By Ostwald's catalytic oxidation process, however, it has been possible to carry out this trans-



FIG. 19. LINDE-FRANK-CARO APPARATUS FOR PRODUCING HYDROGEN

²See also METALLURGICAL AND CHEMICAL ENGINEERING for April, 1913.

³Die Industrie der Ammoniak und Cyanverbindungen, Leipzig 1915.

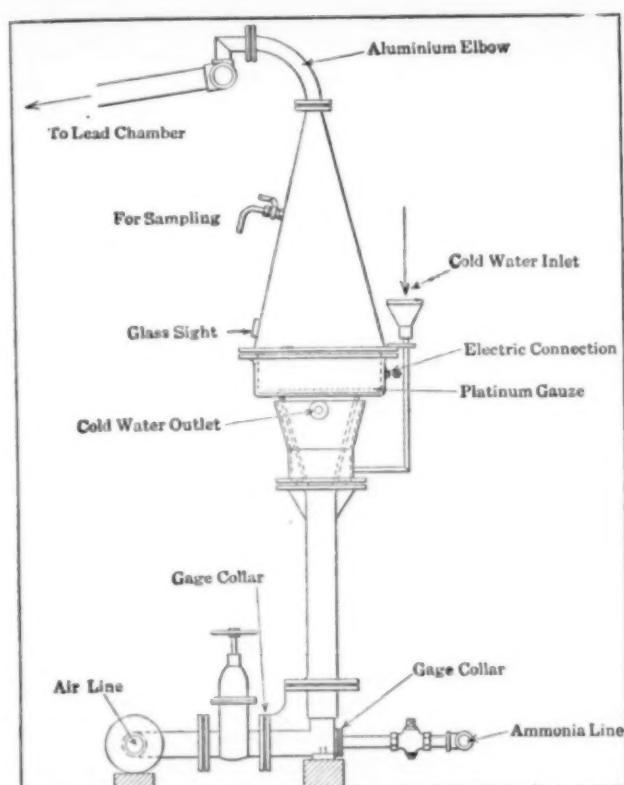
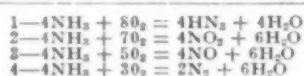


FIG. 20. OSTWALD CATALYZING APPARATUS FOR OXIDATION OF AMMONIA. OLDER TYPE

formation before the nitrogen is applied to the soil, which naturally has many advantages.

As an example of the reaction processes between ammonia and oxygen, the following formulæ may be of interest:



In general, the reaction is regulated so as to proceed according to formula 3. Above all, it is endeavored to avoid the nitrogen losses of equation 4. The most generally used catalyst for this process is a fine-mesh platinum net, which is heated electrically to a temperature around 700 deg. C. It is claimed, however, that other catalysts, not containing platinum, are in use in Germany. The mixture of ammonia and air is led at a high velocity through the catalyst, so that the time of contact is only 1/100 sec.

An authentic view of an Ostwald apparatus, as it is now built, is not available. Fig. 20, taken from METALLURGICAL AND CHEMICAL ENGINEERING for 1916, shows an apparatus as actually built and intended for production of nitrous gases for sulphuric acid manufacture according to the chamber process, but this design deviates quite considerably from the design used at present. The illustration will, however, serve to give an approximate idea of what the machine looks like. As to their capacity, the earlier types were capable of producing 200 kg. 53 per cent nitric acid per 24 hours, but considerably larger apparatus are now built in Germany, where the process, as known, is now used to a very great extent.

From a technical point of view the Ostwald oxidation process has been considerably improved since it first

began to be used on a commercial scale. In the first factory, at Gehrte, near Berlin, a nitrogen exchange of only about 75 to 80 per cent was obtained, while now 90 per cent is reached and even 92 and 93 per cent are claimed. Particularly on account of the fact that the catalyst gradually loses its activating power, an average value of 90 per cent may be considered conservative.

ECONOMICAL ASPECTS OF THE DIFFERENT PROCESSES

Having now briefly described the different methods for producing nitric acid from atmospheric nitrogen, a few words will be given in regard to the economic side of the problem. For some time there has been and is still quite a difference of opinion as to which one of the processes is the most economical and which one offers the greatest promise for the future. In particular this controversy has been with respect to the production of nitrogenous fertilizer materials. It would take too much space to go into this question, and I will only consider the manufacture of nitric acid with atmospheric nitrogen as a starting point, as this problem is in our case of a greater interest.

We will then first see how the price of nitrogen in its different forms stood before the war, and base our calculations on these prices. It must, however, be pointed out that the nitrogen prices will undoubtedly change quite considerably after the war, and the relation between the nitrogen values of the different products may also be quite different.

The prices in Germany before the war were about as follows:

Chile saltpeter, 95%—	
(15.5% N.).....	= 185 Mk. = 1200 Mk. per ton nitrogen
Ammonium sulphate 25%—	
(20.5% N.).....	= 275 Mk. = 1350 Mk. per ton nitrogen
Calcium cyanamid—	
20% N.).....	= 210 Mk. = 1050 Mk. per ton nitrogen
Calcium nitrate—	
(13% N.).....	= 156 Mk. = 1200 Mk. per ton nitrogen
Nitric acid, 53%—	
(11% N.).....	= 194 Mk. = 1650 Mk. per ton nitrogen
Nitric acid, 93%—	
20% N.).....	= 390 Mk. = 1900 Mk. per ton nitrogen
Ammonium nitrate—	
35% N.).....	= 610 Mk. = 1750 Mk. per ton nitrogen

Using Chile saltpeter as a starting material and a saltpeter price of 185 Mk. per ton, it would be possible to manufacture and sell the concentrated 93 per cent nitric acid at a price of 390 Mk. per ton. We will now try to find what price we can figure with, for electric energy on the one hand and for the different materials required for producing ammonia on the other, in order to manufacture nitric acid at the same cost, both by the direct-arc method and by using the Ostwald oxidation method.

a. Birkeland-Eyde process:

Assumption: A factory with a yearly production of 10,000 tons = 2200 tons nitrogen. Cost of installation, 2000 Mk. per ton nitrogen per year.

The costs will then be as follows:

	Per ton. Nitrogen
Interest and amortization, 15% on 2000.....	300 Mk.
Labor	90 Mk.
Misc. materials	70 Mk.
General expense	100 Mk.
Net cost of production exclusive of power.....	560 Mk.
Selling price per ton, nitrogen.....	1900 Mk.
Balance for power and profit.....	1340 Mk.
With a profit of 15% on 1900 Mk.	= 285 Mk.
the price of power (9.3 Kw. years) could be.....	= 1055 Mk.
Corresponding to a price of 113.4 Mk. per Kw. year.	

b. Ammonia oxidation:

Same assumption concerning production,

i. e., 2200 tons nitrogen.

Cost of installation according to Diffenbach,

1500 Mk. per ton nitrogen per year.

The costs will then be as follows:

	Per ton, Nitrogen
Interest and amortization, 10% on 1500.....	150 Mk.
Conversion cost, exclusive of nitrogen losses but including concentration cost	500 Mk.
Net cost of production, excluding NH_3	650 Mk.
Selling price per ton, nitrogen.....	1900 Mk.
Balance for ammonia and profit.....	1250 Mk.
With a profit of 15% on 1900 Mk.....	= 285 Mk.
The price of the ammonia-nitrogen, 1100 tons, could be =	965 Mk.
Corresponding to a nitrogen price of 875 Mk. per ton.	

The calculations show therefore that in order to compete with the manufacture of concentrated nitric acid from Chile saltpeter at a price of 185 Mk. per ton, the energy for the arc process can not cost more than about 113 Mk. per kilowatt-year, or also, if the acid is to be manufactured from ammonia, this can not cost more than 870 Mk. per ton nitrogen.

The power value of 113 Mk. per kilowatt-year corresponds to 1.32 pf. per kilowatt-hour, a figure which undoubtedly can be reached in Germany with the modern gas engines and steam turbines.

Concerning the nitric acid manufacture according to the arc process in other countries with cheap water power, even if not as cheap as in Norway, it clearly shows that such a manufacture from an economical standpoint is much more advantageous than the production from Chile saltpeter.

If we now investigate in what ways we can produce ammonia with a nitrogen value of 875 Mk. per ton, we find that we cannot start out from ammonium sulphate as this has a nitrogen value in itself of 1350 Mk. per ton, or 275 Mk. per ton ammonium sulphate. At this price of ammonium sulphate, the nitrogen value of the ammonia liquor at coke or gas works can be assumed to be 1050 Mk., but in general this value is not taken higher than 850 Mk. per ton nitrogen. It would therefore not be profitable to convert this ammonia-nitrogen into nitric acid, if the nitrogen value in the concentrated nitric acid was not higher than 1900 Mk. per ton.

As far as the lime-nitrogen is concerned, its selling price in the German market has for the past years been around 200 to 210 Mk., corresponding to a nitrogen value of 1000 to 1050 Mk. per ton. At such a price it is evident that it would not pay to convert the cyanamid into ammonia and use this for the manufacture of nitric acid, when the conversion cost alone, the nitrogen losses inclusive, may amount to about 240 Mk. per ton nitrogen; that is, the nitrogen value in the finished ammonia would be nearly 1300 Mk. per ton.

It may therefore be said that the nitrogen in ammonia cannot cost more than 750 to 800 Mk. per ton; that is, 150 to 160 Mk. per ton 20 per cent. cyanamid, if the proposition shall pay.

With this, it should not be understood that it is entirely impossible, with a relatively high cost of power and a low cost of coke, to use the cyanamid-oxidation process for manufacturing nitric acid.

Looking into the possibilities of making nitric acid from ammonia produced according to the Haber process, we have here very meager data on which to base our assumption. The production cost of synthetic am-

monia is, as previously mentioned, a secret, and only that part comprising raw material and power can be estimated with fair accuracy. According to what has been previously stated, the cost of the raw material should not have to exceed 24.4 pf. per kg. nitrogen, and the power cost can be figured at approximately 2 pf. per kg. nitrogen, or a total of 26.4 pf. We may, however, be on the safe side if we assume the other production costs to be 40 pf. per kg. nitrogen at the most, much lower figures having been reported. This then gives a total cost of 66 pf. per kg. nitrogen. If this estimate is fairly accurate, it shows that even under normal conditions synthetic ammonia can be converted into concentrated nitric acid at a good profit.

THE WARRING NATIONS' PROVISION OF NITROGEN

After the previous account of the natural nitrogen resources which are at the disposal of the warring nations, and the possibilities for utilizing atmospheric nitrogen, I will now endeavor to give an idea of how each country provides for its nitrogen requirements.

We will then begin with the entente countries, including America. Although this country as yet is not in open war* with the central powers, its nitrogen resources are entirely at the disposal of the entente. As previously mentioned, the nitrogen which is used for war purposes is principally in the form of nitrates or nitric acid, although smaller quantities in the form of ammonia-nitrogen are used, for example in explosives containing ammonium nitrate, etc.

The most important nitrogen source for the entente is therefore the Chile saltpeter deposits. By again referring to the diagram, Fig. 6, of the Chile saltpeter production, we can gain an approximate idea of how much the entente can obtain from this source. After a rapid decline in the production during the latter part of 1914 and 1915, the immediate cause of which was the stopping of the export to Germany, it reached in 1916 not only the record figure of 1913, but exceeded this by about 15,000 tons nitrogen. With exception of the small quantities which went to neutral countries, all of this was taken by the entente. It is difficult to estimate how large a part of this was used for fertilizers, but an approximate idea can be had by considering the different countries' saltpeter import before the war. We know, for example, that of 500,000 tons of saltpeter normally imported by America per year about 200,000 tons is used for explosives. Figuring, furthermore, 50,000 tons for other chemical industries, there remains for fertilizers about 250,000 tons. Assuming that this quantity has not been increased during the war, we would find that of America's import for 1916, amounting to about 1,200,000 tons, not less than 950,000 tons of nitrogen was used in the explosive industry. We know further that before the war about 80,000 tons of saltpeter was exported from Chile to other countries than Europe and America, principally to Japan, and possibly this was mostly used for fertilizers. During 1916 this figure rose to 140,000 tons, and the increase, 60,000 tons, corresponding to 9,500 tons nitrogen, can be assumed to have been Japan's contribution to the entente's ammunition supply. The normal shipments to Europe, not including Germany, immediately before the war amounted to 1,250,000 tons. It is generally

*Author's paper was read Feb. 8, 1917. The United States declared war in April, 1917, and subsequently planned for the production of nitric acid from the air.—Ed.

estimated that from three-fourths to four-fifths of the European saltpeter import is used for fertilizers, and from this it follows that the European agricultural industry, not including Germany, before the war broke out, used about 940,000 to 1,000,000 tons saltpeter. This figure has, possibly on account of the scarcity of tonnage, rather been reduced than increased during the war. During 1916 about 1,600,000 tons was shipped to Europe, and if we subtract from this the above fertilizer requirements the balance for explosive purposes would amount to from 600,000 to 640,000 tons, corresponding to from 95,000 to 100,000 tons nitrogen.

Adding together the above figures, we find that the entente during 1916 had more than 1,650,000 tons of saltpeter, corresponding to 260,000 nitrogen, for its production of ammunition, an amount which equalled the world consumption at the time of the Russia-Japan war.

The other large nitrogen source is, as before mentioned, the coal out of which nitrogen is obtained in the form of ammonia or ammonium sulphate. I have previously shown that of the world's ammonium sulphate production about one-third comes from England, one-third from Germany and one-third from the other countries, these proportions being before the war. While Germany's production has increased rapidly during the past years, England's production has remained at a little over 400,000 tons. America's production has shown a rapid increase since the war began and amounted to 325,000 tons in 1916. In the other entente countries it may be assumed that the production has fallen from about 140,000 tons before the war to from 75,000 to 100,000 tons, since a great portion of the Belgian and French coal fields have been captured by the Germans.

The entente countries can therefore together be assumed to be able to produce over 850,000 to 900,000 tons of ammonium sulphate or 175,000 to 185,000 tons of ammonia-nitrogen. For their ammunition manufacture this is not of such great importance, as the conversion thereof to nitric acid is done to a very small extent. Only a few factories working on the Ostwald principle are in operation in England. Part of it, however, goes into the manufacture of ammonium nitrate, which is used for mines, bombs, etc. On the other hand, it is possible that part of the ammonia-nitrogen may indirectly benefit the ammunition production, in that part of the Chile saltpeter for fertilizer purposes can be substituted by ammonium sulphate, and that consequently the actual use of saltpeter is greater than figured above.

As to the utilization of atmospheric nitrogen for the manufacture of explosives, there are only two processes which to any degree can serve to fill the nitrogen demand of the entente countries. These are the arc and the cyanamid processes.

Of the arc processes that of Birkeland-Eyde takes unquestionably the first place. Although there are no installations of importance outside of Norway, large plants are planned both in America and Russia. As far as America is concerned, a great controversy is going on there at the present as to how the nitrogen question shall best be solved, the military authorities estimating that the yearly requirements for nitric acid

The product of the Norwegian factories, in which in case of war would be 180,000 tons.

The product of the Norwegian factories, in which mostly French and English capital is invested, goes mainly to the entente. At present, since the Rjukan II plant has been put in operation, about 350,000 horsepower is utilized, which at a production of about 80 kg. nitrogen per horsepower year would correspond to 28,000 tons of nitrogen per year. Of this at least 20,000 tons goes to the entente, principally in the form of ammonium nitrate.

Washburn stated in 1916 that at that time about 500,000 horsepower was used in the manufacture of atmospheric nitrogen products for the entente powers. I suppose this included the power consumption of the Norwegian Nitrogen Company. If such is the case, it is possible that the largest part of the balance, 150,000 horsepower, has been used in the manufacture of cyanamid and would give about 50,000 tons of nitrogen. How much of this was used for explosives in the form of nitric acid is difficult to estimate, but the amount certainly was comparatively unimportant. On the other hand, a large part was undoubtedly used for the manufacture of ammonium nitrate, and we know that almost the entire Norwegian cyanamid production goes to the Norwegian Nitrogen Company's factories, where it is made into ammonia and treated with nitric acid for the production of ammonium nitrate, about 300 tons being produced per day. It is possible that both the French and the American cyanamid is used in the same way.

When we come finally to the question as to how the Central powers obtain their nitrogen supply, we have very meager data on which to base our estimates. We know only that it falls on Germany to obtain the required supply, and we know also fairly well what processes are used for that purpose.

As has been said previously, Germany undoubtedly had an enormous saltpeter stock on hand at the outbreak of the war, and it is claimed, besides, that as long as Italy remained neutral not inconsiderable quantities of saltpeter were imported that way. As soon as Germany found itself unable to keep up its saltpeter import an intensive activity was at once started for building up an atmospheric-nitrogen industry, large enough to supply Germany and its allies with their requirements. The means which were followed for this purpose seem to be as follows:

1. Increase of the ammonia production at coke and gas works.
2. Manufacture of ammonia by the cyanamid process.
3. Synthetic production of ammonia according to Haber's method.
4. Conversion of ammonia into nitric acid by the Ostwald method.
5. Manufacture of nitric acid by the arc process (Pauling's, etc.).

How large quantities of nitrogen products the Central powers have been able to obtain by the above methods is naturally very difficult to estimate accurately, and the reports in the technical press relating thereto are very meager and contradictory. The following can therefore only be a very approximate estimate thereof.

Considering first the ammonium sulphate, we find from an article in *Kunstdünger und Leim-Zeitung* for 1916 that Germany's ammonium sulphate production for 1917 is estimated to reach about 700,000 tons, or 140,000 tons of nitrogen. This figure, however, seems

to be entirely too low, because as previously pointed out (see Fig. 9), already in 1913 it amounted to 110,000 tons of nitrogen, and it is known with certainty that the distillation of coal has increased enormously since the beginning of the war. If we, however, take the value 140,000 to represent Germany's production, we may safely assume that the total production of the Central powers is fully 200,000 tons.

At the outbreak of the war there were in Germany and Austria six cyanamid factories with a combined capacity of 60,000 tons. The enormous expansion of this industry during the war follows also from the above article, which states Germany's cyanamid production during 1917 is estimated at 400,000 tons, corresponding to 80,000 tons of nitrogen. Several new factories also have been built in Austria and Hungary since the war started, and the total production of the Central powers in the form of lime-nitrogen may reach at least 120,000 tons of nitrogen.

As also previously mentioned, the first factory for the manufacture of synthetic ammonia according to the Haber process in 1913 had a capacity of 30,000 tons of ammonium sulphate. In 1915 the production was five times this, and for 1916 the production is reported as 300,000 tons, figured as ammonia. At least two new very large factories are at present under construction, so that for 1917 we can safely figure on an ammonia production of 500,000 tons, corresponding to

100,000 tons of nitrogen. In addition, there is one large factory being built in Austria.

The Central powers' production of ammonia-nitrogen would therefore, according to the above figures, total 420,000 tons. What portion of this, in the form of ammonium sulphate or lime-nitrogen, is used for agricultural purposes is difficult to estimate, but it is very likely that the uses for this purpose have had to be somewhat reduced. Before the war 146,000 tons of nitrogen was used for this purpose in Germany. Assuming that, together, the Central powers at present consume 175,000 tons of nitrogen for fertilizing purposes, then at least 245,000 tons of ammonia-nitrogen would be available for military use, the greater part, however, only after it had been converted into nitric acid. On account of losses in this conversion, the above amount will have to be reduced by 10 per cent., that is, to 220,000 tons. This figure shows what enormous application the Ostwald process has found in Germany.

Finally, as to the arc process, the use thereof in Germany and Austria must be relatively small, as the supply of cheap power is scarce. Notwithstanding this fact, the process has come into use for the manufacture of nitric acid, although to a comparatively small extent. It is principally the Kock and Pauling methods which have been applied, steam and gas power being used for supplying the electric energy. According to one trustworthy source of information, not less than 100,000 horsepower should at present be used for this purpose, corresponding to a nitrogen production of 8,000 tons per year.

If the latter figure is included, the total available nitrogen supply of the Central powers for military purposes could therefore be roughly estimated as 225,000 tons per year, and the figure given by Landis in METALLURGICAL AND CHEMICAL ENGINEERING for 1916 is entirely too low. He estimates the saltpeter consumption for Germany at 100 tons of HNO_3 per day, equal to 80,000 tons of nitrogen per year.

In the diagram, Fig. 21, an endeavor has been made to graphically represent the above figures regarding the nitrogen resources of the Entente and Central powers. Without claiming any high degree of accuracy, this diagram can, however, serve to answer the question: "How do the warring nations obtain their nitrogen supply?"

Deterioration in Heating Value of Coal.—A report on the deterioration in the heating value of coal during storage, covering a five-year period, has just been issued by the Bureau of Mines, as Bulletin 136. Horace C. Porter and F. K. Ovitz are the authors.

The tests show that the amount of deterioration of coal in heating value during storage has commonly been overestimated. Except for the subbituminous Wyoming coal, no loss was observed in outdoor weathering greater than 1.2 per cent in the first year, or 2.1 per cent in two years.

The loss in heating value is given for New River and Pittsburgh coals during five years' storage in the open air and under water, for Pocahontas during two years' storage in the air, and for Sheridan, Wyoming, coal during two and three-quarters years' storage in the air.

The Bulletin can be obtained on application to the Directory, Bureau of Mines, Washington, D. C.

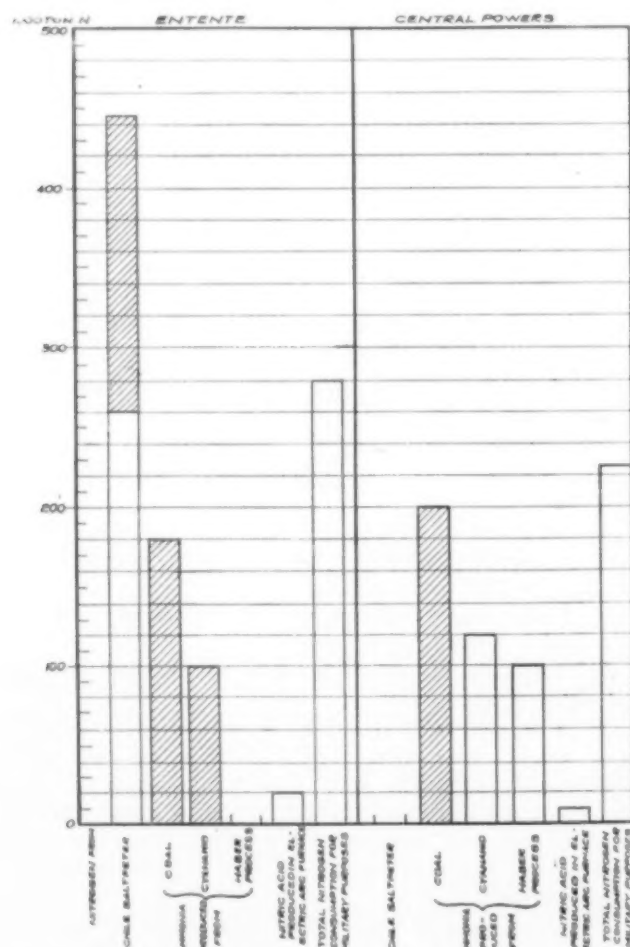


FIG. 21. GRAPHIC REPRESENTATION OF THE WARRING NATION'S NITROGEN RESOURCES. (THE SECTIONED PART OF THE COLUMNS REPRESENT THE NITROGEN USED FOR FERTILIZER.)

Present Progress and Development of the Electric Furnace in Non-Ferrous Metallurgy*

By Dwight D. Miller

Engineering Department, Society for Electrical Development

Regarding what has been and is being done to develop an electric furnace for use in the non-ferrous field, it can be said that there is under way at present much experimentation, though with not a great deal of actual accomplishment so far as the number of furnaces in commercial use is concerned.

The object of this experimentation is of course to develop an electric furnace which shall have not only high thermal efficiency but which shall be able also to handle yellow brass with small metal loss—and if possible one which shall be able to handle various alloys as the requirements of the foundry may demand. In working out this problem, simplicity in construction and reliability of operation should take precedence, since obviously a furnace which will operate continuously without electrical trouble or breakdowns, although it may not be quite as efficient as another type which is subject to these interruptions and delays, will turn out more metal of the desired quality for a given time and power consumption—will have the greater over-all efficiency of the two.

What is really needed to solve this problem is a combination of electrical and metallurgical knowledge. It is a comparatively easy matter for the electrical engineer to turn out a furnace which combines simplicity, reliability with high efficiency, one which will give ample heat for the process to be performed, but unless he knows just how the application of this heat at a certain temperature is going to affect the metals composing the alloys which volatilize at comparatively low temperatures, the metal losses of the process will be large. To correct this condition metallurgical knowledge is essential.

Alloys of low zinc content or those that melt at low temperatures do not present the same difficulty as do those with high zinc content which must be poured at the higher temperatures.

Dr. Gillett has explained the reason for this, namely, that since the alloys are poured at about 150°C. above their melting temperatures, those alloys which contain 30 to 40 per cent zinc are poured at a temperature but slightly below their boiling points with a vapor pressure of very nearly one atmosphere—hence the larger loss through vaporization.

There are a number of bright minds now at work on this problem, and it is to be hoped that practical commercial furnaces to meet the various conditions encountered in the non-ferrous industries will soon appear in addition to those already in use, thus establishing the electric furnace in the same permanent commercial position as it now occupies in the steel industry.

FURNACES UNDER EXPERIMENTATION.

The furnaces which have been designed and are now under experimentation include the Gillett furnace (indirect-arc type), patent assigned to the government, Department of Interior, Bureau of Mines; the Conley

furnace (molded-resistor type), controlled by Florence & Hampton, 1270 Broadway, New York; the Thomson-FitzGerald furnace (reverberatory resistance type), controlled by John Thomson, 253 Broadway, New York; the Northrup furnace (induction type without iron core), controlled by the Ajax Metal Company, Philadelphia; the Hering "pinch-effect" furnace, controlled by Carl Hering, Philadelphia, although an option is held by the Ajax Metal Company for handling brass in the furnace.

The Gillett furnace, invented by Dr. H. W. Gillett, is an indirect arc furnace so designed as to bring about a violent agitation of the charge by a rocking motion. While the writer was privileged to witness some of the tests that have been going on during the summer, he is not in a position to reveal any of the results so far attained. It is hoped that Dr. Gillett will soon be in a position to make his findings public.

The Conley furnace, invented by William H. Hampton, is a resistance furnace of the molded-resistor type, in that the charge is melted in an open graphite crucible which closes the secondary circuit. The furnace is supported on trunnions and is poured by tipping through the mechanism of worm gears, chains and sprockets. It is balanced by counter-weights and can be tipped very easily.

The current is brought in by bus-bars and flexible cables, the ends of which are permanently connected to the sides of the crucible by graphite cement. This crucible is contained in a rectangular enclosure made of iron plates and packed with kieselguhr, the heating effect being obtained by radiation through the crucible walls.

The control is by hand-operated dial switches in the primary circuit giving varying voltage in the secondary, ranging from 10 to 20 volts. This method of operation gives a steady load, the only fluctuation which takes place being a very slight one due to the change in the resistance of the crucible as it heats up. The furnace is designed for single-phase operation at prevailing frequencies.

Some of the claims made by the inventor include: (1) A furnace which is revolutionary in the modern methods of melting, which can be used for melting any metals or making any alloys. (2) This construction gives absolute control over contents of furnace excluding all foreign matter, and accurate heat control—much more so than in the case of the arc furnace. (3) The melt is made faster with better product in that it is more homogeneous and can be held closer to specifications. (4) The total metal loss including volatilization and spillings is less than two-tenths of one per cent. (5) The furnace can be constructed to take a crucible of 1200 lb. capacity or larger and, while designed, as far as current-carrying capacity is concerned, to handle 20 kw. per 100 lb. melt, it is capable of melting 100 lb. of copper with 12 kw.-hr. input. The power factor is practically unity—98 to 99 per cent.

Regarding the Thomson-FitzGerald furnace, invented jointly by John Thomson and Francis A. J. FitzGerald, there is not at present a great deal to say, since it is not being pushed. The apparatus is designed for the purification of spelter containing deleterious metals by distillation in an electric furnace, and has been tested mainly for the fuming of impure zinc and condensing it as a highly refined metal. It is a resistance furnace

*Part of a paper presented at the meeting of the American Institute of Metals, Boston, Sept. 24, 1917. The introduction of the paper was reviewed in a report of the meeting in our issue for Oct. 1, 1917.

of the reverberatory type—the heating effect taking place by radiation from specially formed resistors and reflected to the charge from the walls and roof of the furnace inclosure. It is used in conjunction with a condenser into which the fumes escape through specially constructed passages.

Mr. Thomson advises that it is suitable for melting brass and bronze, which can be carried on simultaneously by subdividing the open retort; also that small melts of various alloys can be handled by crucibles set into the retort. For large melts the metal may be ladled out, tapped out or poured out through a spout by tilting.

The furnace underwent a series of tests at the Fitzgerald Laboratories, Niagara Falls, and while it was successful in producing extremely pure zinc, no other data are available for publication as to its performance. It has never been in commercial use in this country.

The Northrup furnace, invented by Prof. Edward F. Northrup of Princeton University, has been under experimentation for the past year, during which time considerable data have been obtained. The furnace is an absolutely new departure in furnace design and principle of operation. It is readily adapted to handle almost any kind of metal and uses an oscillating current at very high voltage, being stepped up to 10,000 volts. The oscillations are produced by discharges from a condenser and the energy conducted to a series of closed coils which are mounted concentrically and insulated from each other. These coils completely surround a cylindrical crucible in which the charge is melted. A 20-kw. furnace will melt 45 lb. of brass scrap in 35 minutes, starting from the cold. Temperatures as high as 1600 deg. C. are readily obtained. The furnace is admirably adapted to make melts in vacuum, and is now being used by the writer for melting both glass and electrical conducting materials.

Mr. Clamer of the Ajax Metal Company has the following to say about it: "Judging from the results thus far obtained with this type of furnace in its early development stage, it has very good prospects of becoming a commercially successful furnace for filling the gap in the fields covered by other electric furnaces thus far produced, i.e., that it will be an efficient melting device, having all the flexibility of the crucible melting furnace. It can be used with or without crucibles, does not require a liquid charge for starting, and it is therefore possible to empty the crucible entirely after each melting, making it possible to change readily from one mixture to another. As an exceedingly small amount of refractory material is required, owing to the large amount of energy which can be readily converted into heat in a small body of metal, the furnace reaches highest efficiency on the second heat. It is therefore a furnace which can be successfully used in 9 or 10-hr. per day service."

So far as the writer is aware nothing at present is being done with the Hering "pinch effect" furnace. The furnace has been fully described in the technical press both by Mr. Hering himself and others.

It will be interesting to note whether as these various furnaces are put into commercial use they actually meet the above claims which have been made on the basis purely of design or as the result of experimental tests.

FURNACES IN COMMERCIAL USE

The furnaces that are in actual commercial practice for handling copper-zinc alloys include the Ajax Wyatt furnace, controlled by the Ajax Metal Company, Philadelphia; the Foley furnace, controlled by Charles B. Foley, Inc., 170 Broadway, New York; the Baily furnace (reverberatory resistance type), controlled by the Electric Furnace Company of America, Alliance, Ohio; the Rennerfelt furnace (indirect-arc type), represented by Hamilton & Hansel, 17 Battery Place, New York; the Snyder furnace (direct-arc type), controlled by the Industrial Electric Furnace Company, 53 West Jackson Boulevard, Chicago, and the Hoskins furnace (resistance type), controlled by the Hoskins Manufacturing Company, Detroit, Mich.

William A. Rogers Co., Ltd., states with reference to the Baily furnace that there are practically no metal losses handling silver, which is done in two crucibles holding approximately 500 oz. each, and that the metal appears more homogeneous—a better melt. They melt pure silver, copper anode scrap and chlorides, thus recovering the silver from their electrolytic process for plating. The first heat takes about 1 hour and 30 minutes, while the others take approximately 1 hour. The average total time for charging, melting and pouring being approximately 1 hour and 7 minutes, they can get about eight heats (of two crucibles each) in a day of 10 hours. The pouring temperature is around 2200 deg. Fahr., although no pyrometer is used, the temperature being judged by the color. They run with a constant input of 30 kw., which figures out 960 kw.-hr. per ton. The reason for the better melt obtained in the electric furnace is better control. They formerly used an oil furnace, but found that the quality of the oil varied considerably so that it was almost impossible to get uniform heating throughout the crucibles, necessitating pouring at 2500 deg. Fahr. in order to get good castings (flat blanks) as against 2000-2200 deg. Fahr. with electric heat. They also had trouble with water in the air pipes. By doing away with the oil pump and air compressor they were able to obtain much better insurance rates. The electrodes in the silver furnace are replaced once every three months; but as they use the butts left over from the annealing furnaces, this renewal costs them practically nothing.

Regarding the annealing furnaces, two of which are in use for annealing German silver and brass blanks, they can handle 9 tons in 10 hours annealing at 1450 deg. Fahr. with 175 kw., although the furnaces are rated at 200 kw. for this work. The current supplied to the plant is single-phase, 25-cycle, 440-volt. They have an arrangement whereby the current is supplied at a flat rate for a certain maximum 24-hour supply. In order to keep within this maximum they operate the silver furnace and motors in the plant during the day and the annealing furnaces during the night, which take 60-kw. when running full capacity. If, however, the motor day-load permits, the annealing furnaces are run during the day also at about 25-kw. input. Regarding the item of savings, this is considerable both in regard to pickling acid and labor required on account of cleaner metal.

The Otis Elevator Co. has two annealing furnaces, 300-kw. and 150-kw. capacity, for treating steel and brass castings. About the only trouble experienced has

been an occasional cracking of the resistor-troughs, necessitating patching. They operate these two furnaces from one three-phase transformer, the larger furnace operating two-phase and the smaller single-phase, the troughs of which are in series, thus producing an even balanced load.

The castings treated vary from 3 lb. up to 7000 lb. each. The larger furnace can handle a charge up to 12,000 lb. of metal, while 7500 lb. can be charged in the small furnace. The metal is treated at a temperature ranging from 1500 deg. Fahr. to 1850 deg. Fahr. and held anywhere from 16 to 20 hours. Starting with a furnace temperature of approximately 750 deg. Fahr. and running up to an annealing temperature of 1600 deg. Fahr. at which time the current was shut off, the cost per ton was approximately \$7, the total time the power was on being 19 $\frac{3}{4}$ hours.

At the Lumen Bearing Co., Buffalo, they handle copper, lumen metal, phosphor and manganese-bronze. They charge 600 lb. consisting of scrap and ingots. Short test runs on both lumen metal and phosphor-bronze under far from ideal conditions resulted in a consumption of 12 kw.-hr. for lumen and 22 kw.-hr. for phosphor-bronze per 100 lb. They state, however, that as soon as they get running 10 hours per day of six days in the week they expect to reduce these figures to 10 and 17.5 kw. respectively based on making the hardener, used with lumen metal and forming 28 per cent. of the melt, separately in a crucible.

The lumen metal is poured from 1250-1600 deg. Fahr., the phosphor-bronze at approximately 2200 deg. Fahr. The heats average about one hour, so that eight or nine heats can be made in a 10-hour day, according to conditions. The metal loss will vary between 2 $\frac{1}{2}$ to 3 $\frac{1}{2}$ per cent for the lumen metal, the test on the phosphor-bronze showing 2 per cent.

With the idea of getting the hearth in good condition, a melt of copper, 1512 lb., was run just previous to the test run on phosphor-bronze. This was held for 4 hours and 20 minutes with a consumption of 24.8 kw.-hr. per 100, starting with furnace hot. The charging was done in nine separate lots extending over three hours, while six pours were made, ranging from 2000 deg. to 2100 deg. Fahr., in 40 minutes. Under these conditions the figures given should not be considered as a true indication of the performance of the furnace when handling copper.

It is possible to charge manganese-bronze immediately after a lumen heat, since the zinc which might be left in the furnace would have no injurious effect on the manganese bronze.

Of the two furnaces installed one has been in operation for six months and the other for two months. During this time there has been only one renewal of the bottom costing about \$50, with some slight patching of same. The second furnace, however, is not run every day.

Regarding savings, the statement is made that with coke costing \$4 and crucibles 4 cents per number there is a saving made by using electricity of $\frac{3}{4}$ cents per kilowatt-hour, which is practically what they pay. In addition the labor of carrying the coke and ashes is eliminated, together with the space for their storage.

In melting the alloys a small opening is left in the spout through which the vapor simmers out from time to time and is caught in hoods located permanently just

above the spout. These hoods also carry off the escaping vapors when pouring.

By operating in this manner no pressure is built up within the furnace and it presents a rather nice question as to whether the metal loss would be less or greater when operating with a tightly closed furnace, building up thereby quite a pressure which causes the vapor to rush out with considerable force when the furnace is opened for pouring. The amount simmering out of the opening during the melt is trifling, since the zinc vapor is heavier than the atmosphere and is held by the saucer-shaped hearth of the furnace.

There is one more or less serious drawback to the Baily furnace in that it is very sluggish. It takes something like 15 minutes before it begins to respond to a change in power input, while as a matter of fact there isn't much change in temperature for an hour. At the Lumen Bearing Co. the last heat of the day is made on practically the stored heat of the furnace. In fact, it took them 49 hours to cool the furnace from 2580 deg. to 965 deg. Fahr. This sluggishness means that if the furnace is brought to too high a temperature in the morning at the beginning of the day's melt, the metal is apt to be burned and much time lost before the proper temperature can be obtained. On the other hand, it is of advantage in keeping a hot furnace overnight.

In connection with the other three furnaces in use, i.e., the Rennerfeld, Snyder and Hoskins, it can be said that they are of the indirect-arc, direct-arc and resistance types respectively. They have been fully described many times and are no doubt well known in both the ferrous and non-ferrous fields.

The Hoskins furnace is sold mainly for work of a more or less experimental nature as called for in the laboratory and testing room, or when it is desired to melt a small batch of metal occasionally. The manufacturers do not recommend it for commercial purposes.

They use two of their F. C. (crucible chambers) melting type furnaces continuously for melting their own nickel-chromium alloys. The smaller one takes one crucible No. 12 or No. 14 and the larger holds two crucibles of the same size. They give the following information regarding the performance of these furnaces:

"The smaller, holding one crucible, usually gives four to five heats of 23 lb. each per day, but we have no power figures on it. It is lined with 4 $\frac{1}{2}$ -in. magnesite back of the resistor and 4 $\frac{1}{2}$ -in. fire-brick back of this. This brick lining has to be rebuilt every six to eight weeks, and is patched every Saturday.

"The larger furnace, taking two crucibles, is lined with 4 $\frac{1}{2}$ -in. carborundum bricks just back of the resistor, with 3-in. powdered silica back of this, and finally 2 $\frac{1}{2}$ -in. kieselguhr brick back of this. This construction has to be rebuilt every three or four months, but it is patched every Saturday. In this furnace the current is turned on every morning at 4.30, increased at 7 a. m. to probably 40 kw., when charging begins, and later run at 50 to 60 kw. Five heats of 23 lb. each are usually gotten out per day, the first around 11 a. m. and the others every 1 $\frac{1}{3}$ to 1 $\frac{1}{2}$ hours, using for the day from 450 to 525 kw.-hr. These alloys are poured at about 2900 deg. Fahr."

The results of five tests on yellow brass 65-85 showed an average of 49 kw.-hr. per 100 lb., pouring at 1950

deg. Fahr. The melt was made in a No. 70 crucible in their F C furnace. The total time per heat, outside of the first, which took $2\frac{1}{2}$ hours, was approximately one hour. Eight tests on red brass showed an average of 36.5 kw.-hr. per 100 lb., pouring at about 2150 to 2175 deg. Fahr. The first and average heat took the same time as for yellow brass. No metal loss was given in either case. The temperature was taken with a Hoskins couple bare.

The only installation of Snyder furnaces handling non-ferrous metals of which the writer is aware is that of the Chicago Bearing Metal Co. There are two furnaces installed there rated at 400 kw., each taking approximately 750 kva., single-phase, 60-cycle, directly from a 12,000-volt line. The secondary line voltage is 220 with an operating voltage from 120 to 160 volts, depending upon conditions. The power factor is in the neighborhood of 60 per cent.

The furnaces have a capacity of about 2000 lb. of metal per heat and the average power consumption is not over 300 kw.-hr. per ton. They operate 24 hours per day, Sundays excepted, and handle a heavily-leaded bronze such as is used for railway car and locomotive bearings. The composition of the metal is approximately 75 per cent copper and the balance lead, tin and miscellaneous impurities in that order of importance, the lead running about 15 per cent. The metal is poured at approximately 2100 deg. Fahr., and while the metal loss is fairly high, mostly lead and some copper, they save about \$12,000 net per month by doing away with the crucibles, since these two furnaces replace forty to fifty coke and oil-fired furnaces. The high metal loss follows naturally from the use of a direct arc furnace, since it is bound to produce a superheated top layer in the bath. There is also a saving made in increased production with smaller floor space. No further information is available as yet.

The Rennerfelt furnace is in operation at the Gerline Brass Foundry Co., Kalamazoo, Mich., 1/3-ton capacity, and at the Philadelphia Mint, 1200-lb. capacity, while two more of 1-ton capacity each will shortly be in operation at the Chicago Bearing Metal Co.'s plant. These furnaces are all designed for two-phase, three-wire operation.

The furnace at the Philadelphia Mint has been in operation only for a short time, so that full data are not available as yet. They handle penny stock and cupro-nickel. The penny stock is composed of 95 per cent copper, the other 5 per cent being made up of zinc and tin. The cupro-nickel is composed of 75 per cent copper and 25 per cent nickel. They make three heats per day, pouring the penny stock at approximately 1950 deg. Fahr. and the cupro-nickel at about 2500 deg. Fahr.

They have also handled some French and Italian coins composed of almost pure nickel, the lining standing up very well, although the melt was at a high temperature. They use a ganister bottom with silica-brick linings. This furnace should give a very good account of itself in handling alloys of this nature.

In the furnace at Gerline Brass Foundry they have been handling red brass, enamel tank (one-half red and one-half yellow brass with not over 22 per cent zinc content) and monel metal, but not much success was attained with yellow brass ingots. They could not handle yellow brass borings at all. This was to be expected, since neither the direct or indirect-arc type of

furnace is suited for handling alloys containing metals which volatilize at comparatively low temperatures, unless some method is provided for overcoming the superheated top layer.

They had some trouble with the lining giving out on the monel metal heats, which, however, might be attributed to lack of skill in operation rather than against the lining itself, in that the metal was melted to a very high temperature (around 2000 deg. Fahr.) in order to pour intricate castings, and the furnace was over-powered. This would seem to be borne out by the fact that nickel was successfully melted at the Philadelphia Mint in the same lining. They also had trouble with deposits of zinc oxide on the carbons just where they passed through the furnace inclosure, causing them to "freeze" so that they could not be moved in or out.

While too much reliance should not be placed on operating figures obtained as the result of experimental runs, and this remark will apply to those previously given, still as an indication of what may be expected the following results are given:

Out of four heats making monel metal castings, three showed no metal loss and the fourth heat a loss of 3.3 per cent. The average of the actual melting time was 3 hours and 48 minutes, with a consumption of approximately 1300 kw.-hr. per ton. The average charge was 549 lb. with an average electrode consumption of 5 lb. per ton.

The result of seven heats making enamel tank castings under fair operating conditions showed an average metal loss of $3\frac{1}{2}$ per cent, with an average of actual melting time of 1 hour and 48 minutes. The average consumption was 537 kw.-hr. per ton, while that for electrode consumption was 2.8 lb. per ton. The average charge was 580 lb. A great many more heats were run on this alloy, but as the records included preheating of furnace, delays, and gave no metal losses, they were not included.

Ten heats were selected from those making red brass castings as representing fair working conditions. The results show the average charge to be 532 lb. with an average of actual melting time of 1 hour and 14 minutes. The average kilowatt-hour consumption was 437 kw.-hr. per ton with an electrode consumption of 2.8 lb. per ton.

It will be noted that the kilowatt-hour required for making red brass castings are less than those for enamel tank, and simply goes to show that experimental figures cannot be relied on for commercial practice. No metal loss was given for these heats, nor were any pouring temperatures given for any of the tests, which help to explain the discrepancy in the results obtained. The enamel tank may have been heated to a much higher temperature. In order to obtain figures of value full, complete data as to all conditions entering into the test should be accurately recorded.

Regarding the whole question of labor savings, it can be stated that arrangements have already been worked out whereby pouring castings or blanks direct from the furnace can be accomplished. In the case of small furnaces these can be picked up bodily and brought to the pouring floor, while in the case of the larger furnaces the molds can be arranged to pass under the spout by means of a conveyor system. An additional advantage to be gained by such practice is the elimination of heat and metal losses when pouring from a ladle.

It will be noted that very little use is made of the pyrometer for accurately recording the temperature of melts. This, in the opinion of the writer, is a mistake and much to be regretted, since the primary object of the use of the electric furnace is to reduce metal losses by more accurate control and the keeping of full and complete daily records which can be used in determining the best practice and eliminating preventable losses. In accomplishing this object the thermo-couple used for measuring temperatures in conjunction with either an indicating or recording instrument is of extreme importance.

One of the objections to using a pyrometer seems to be that accurate temperatures cannot be obtained quickly; that is, by the time the couple has been inserted and a reading taken the metal has fallen off 100 or 200 deg. As already indicated, it is perfectly possible to install the couple permanently in the furnace so that reading can be taken at any time by connecting it with the temperature recording instrument. This should do away with the above-mentioned objection.

This résumé covers fairly completely what has been and is being done, so far as the writer has knowledge, toward the development of an electric furnace for use in non-ferrous metallurgy. The results recorded as to performances are not as full as the writer would have liked to obtain, but it was extremely difficult to obtain them, due to the lack of keeping accurate records. It is to be hoped that the importance of so doing will be fully realized, in order to improve the general practice of to-day. From all indications it is fair to assume that the electric furnace will soon be established on a firm commercial basis as a heating medium in this field.

Ten Per Cent More Coal Will Be Produced in U. S. This Year Than Last.—The Fuel Administration authorizes the following:

Coal production in this country this year will exceed that of last year by 10 per cent. The embargo against sending coal to Canada has been lifted and an arrangement made by which she is to be supplied on a pro rata basis, substantially as though she were a State of the Union. The American Northwest will be properly supplied.

These are of conferences announced recently by Federal Fuel Administrator Harry A. Garfield before his departure for Williamstown. Those present at the conferences were Dr. Garfield; Judge John F. McGee, State fuel administrator for Minnesota, representing the Northwest; W. H. Groverman, representing the dock interests on Lake Michigan and Lake Superior; F. C. Baird, commissioner of the Lake Erie Coal Exchange; and H. P. McCue, assistant fuel controller of Canada.

Not only will this year's coal production exceed that of last year by 10 per cent, but it will exceed that of two years ago by 23½ per cent. These are the figures given Dr. Garfield by Prof. George O. Smith, of the United States Geological Survey.

"The question of shortage for this year," said Dr. Garfield, "will depend then upon whether the American demand has increased by more than the 10 per cent increase in production. If our industrial development, from the war and other causes, has grown beyond that, then we must go short. We have no figures to tell what that development has been."

Chemicals Used in Ore Flotation*

By Oliver C. Ralston† and L. D. Yundt‡

The flotation of minerals from ore-pulps, as practiced at present, involves the use of a small amount of a flotation oil, which so modifies the water in the pulp that a froth is formed and that certain valuable minerals are gathered in the froth. The froth must have sufficient persistence to allow time for separation from the body of the residual ore-pulp. This paper does not deal with the subject of flotation oils, but rather with the other chemicals which are occasionally added to ore-pulps for one reason or another.

The development of ore flotation in a few years to a stage where over 100,000 tons of ore are treated every day in the United States, and half as much again in the rest of the world, threatened, for a time, to disastrously upset market conditions for various products such as pine oil, coal creosotes, coal tar, etc. Incidentally, flotation has also opened a market for other chemicals which formerly could not be used in the western intermountain districts. Chemical engineering has never flourished in these districts on account of the smallness of the market, but it is hoped that ore flotation will now open up new fields for the chemical engineer. The signs of the times point toward the speedy development of sulphuric acid plants at various smelters which are now wasting their sulphur in smoke, and on these plants many other industries will depend. Certain other chemicals will not require sulphuric acid in their manufacture but will soon find a market in these regions, due to the demands of flotation mills and of hydrometallurgical plants.

I shall outline briefly the most important of these chemicals and attempt to set forth the reasons for their use or the theories as to why they have certain definite effects.

ACIDS

Almost the only acid used for flotation work is sulphuric acid which costs less than most of the other available commercial acids. No one knows why the addition of sulphuric acid to certain pulps improves the flotation work. We do know that it often produces a cleaner flotation froth containing less gangue, and also that higher extractions are often made. Further it can reduce the amount of oil necessary to produce the same frothing effect. However, the addition of acid to an ore pulp sometimes proves fatal to good flotation, especially with some copper ores in which a part of the copper has been oxidized by weathering. Such an example is the ore at Inspiration, Arizona. In this latter case the trouble may be due to the formation of enough copper sulphate to spoil flotation, copper sulphate having been found deleterious in the flotation of a number of copper ores. The oxidized copper minerals dissolve easily in very dilute sulphuric acid solutions while the natural copper sulphides are not attacked.

When the addition of sulphuric acid causes an improvement in the flotation of a definite ore, its exact function is rather a difficult thing to explain, and theories are very conflicting. The phenomenon has been known since the very early development of the art. The

*A paper read at the Boston meeting of the American Chemical Society, Sept., 1917. Published by permission of the Director of the Bureau of Mines.
†Metallurgist, U. S. Bureau of Mines, Salt Lake Station.
‡Metallurgical Research Fellow, University of Utah.

Potter-Delprat processes depend on the acid to develop bubbles of gas through interaction on the carbonate minerals in the ore (such as calcite) in order to form a froth, and bubbles of air were not beaten into the pulp. Consequently it was natural that some of the early theories claimed that the addition of acid to a pulp being treated by air flotation, caused an increased number of gas bubbles to form in the pulp and hence facilitated frothing out all the desirable mineral particles. The fallacy of this argument has long been felt.

Electrostatic theories have been advanced to explain flotation and the statement has been made by one theorist that the addition of an electrolyte to the water of the pulp allowed the electrostatic charges on the gangue particles to be conducted away while the charges on the particles of the desired minerals were insulated by a surrounding film of flotation oil. This electrostatic theory was soon exploded, as it rested on a misapprehension as to just what caused charges to appear on suspended particles. The surfaces of small particles suspended in a liquid usually tend to absorb more ions of one electric sign than of the other sign and hence carry apparent electrostatic charges. The thing to be noted, however, is that these charges on the particles are not conducted away by the presence of electrolytes but their existence is dependent upon the presence of ions in the solution. The surface of oil droplets and of air bubbles like absorb ions from solutions, and a certain parallelism between the charges on these various particles of matter and the conditions of good flotation has been observed. Just what is the inner connection has never been explained. It is an interesting fact that one mill in Colorado was reported to receive very pure water from melting snow and that flotation of its ore in this water was very unsatisfactory until the water was contaminated with an electrolyte, sulphuric acid being acceptable among other things.

Bancroft* calls attention to the fact that the acid in ore flotation may not react because of the replaceable hydrogen atom but because of the cutting down of the concentration and consequently the adsorption of the hydroxyl ions. The connection which he wishes to draw with flotation is that "in acid and neutral solutions air seems to be absorbed by organic liquids much more readily than by water," and he thus derives a reason for the attachment of the air bubbles to the oiled sulphides. The preferential adhesion of the oil to the valuable sulphide minerals in the presence of gangue minerals is well known.

The surface tension theories have claimed that the addition of the proper electrolytes, like sulphuric acid so alters the surface tension of the water that frothing can take place. This may be true without conflicting with the colloidal theory but we would call attention to the very small amounts of acid which sometimes produce a marked effect on flotation and the small resulting changes in surface tension of the water. Small amounts of electrolytes are sometimes known to produce profound changes in colloids and we feel more inclined toward the colloidal theory.

Nevertheless, it is not right to claim that the replaceable hydrogen atom has nothing to do with the improvement in flotation results when acid is added. Al-

len and Ralston* have called attention to the fact that if an ore sample is ground dry it is usually necessary to use acid in its flotation, while it is often possible to grind this same ore in a wet condition in a ball or pebble mill and obtain the same flotation results without the use of acid. The natural inference is that the dry grinding has caused oxidized films to form on some of the particles of natural sulphides and that the sulphuric acid was needed to dissolve these films, leaving a clean unaltered surface for the action of the flotation oil and the air bubbles. This, of course, is only a special case and does not claim exception to the colloidal theory in the least.

The amounts used are usually the minimum which have been found to produce a given effect. It varies from two or three pounds of sulphuric acid per ton of ore (contained in three to five tons of water), to as high as one or two hundred pounds of acid. When a large excess of acid is necessary we feel that it must be dissolving off oxidized films while small amounts of acid are probably effective in causing selective adsorption effects. Acid seems to be necessary in the flotation of many sphalerites and iron pyrites. Occasionally a pyritiferous copper ore needs acid. The Anaconda slimes constitute an example of such an ore. The present tendency among flotation men is to find substitutes for acid.

COPPER SULPHATE

So much has been said about the "flotation mystery" involved in the improved results obtained at the Mascot, Tennessee, plant of the American Zinc, Lead & Smelting Co., that a word should be said here. There is no doubt that the use of less than one pound of copper sulphate per ton of ore, suspended in over four tons of water, has caused very much increased recoveries of the sphalerite in their ore and allowed cleaner work. The same effect has been noticed in many other mills treating zinc sulphide ores, although an improvement in the flotation is not necessarily the invariable result of adding copper sulphate to zinc sulphide ores.

At Mascot, the large scale plant was unable to produce commercial results on the ore which had yielded good results in laboratory tests. A bucket of pulp taken from the mill and tested in the laboratory gave good results where the mill failed. At last it was realized that the bronze castings used in the laboratory machine might account for the difference and the hanging of a plate of copper in the mill pulp while it was passing through the large flotation machines corrected the difficulty and led to the discovery of the effect of salts of copper on the flotation of sphalerite. The method by which this discovery was made deserves commendation.

So much then for the fact. Copper sulphate added to the pulp improves the flotation of sphalerite, but it has been called a flotation mystery because no one could explain it. Copper sulphate is deleterious in the flotation of silver ores† and of copper ores; its effects being overcome by precipitation with such a reagent as hydrogen sulphide, sodium sulphide or sodium carbonate.

Neither silver minerals nor copper minerals precipitate copper ions from solutions, but it is well known that natural zinc sulphide reacts with copper sulphate solu-

*Wilder D. Bancroft, "Ore Flotation," Met. & Chem. Eng., 14: 631 (1916).

*Mining and Scientific Press, Jan. 1 and Jan. 8, 1916.

†Min. & Sci. Press, Dec. 18, 1915. An Occasional Correspondent. "Effects of Soluble Components of Ore on Flotation."

tions, precipitating copper sulphide. In fact this reaction is used in the Huff electrostatic separation process for separating zinc sulphide from minerals of the same specific gravity and which are likewise poor electric conductors, such as barite. By soaking the mixture of minerals in a dilute copper sulphate solution a thin imperceptible film of copper sulphide is formed over the zinc sulphide particles and after drying they then act like good conductors and can be caused to jump off of the electrostatic separating machines, leaving the barite behind.

The suggestion is inevitable that in the case of improved flotation of sphalerite the copper going into solution is precipitated as copper sulphide on the surfaces of the zinc sulphide particles, making them capable of better flotation. Why the modified particles float better is the true mystery. Whether the increased electric conductivity of the surfaces of the particles has anything to do with it, or whether copper sulphide has some inherent property of being more easily "oiled," is hard to say. Some rather simple experiments in the physical laboratory might well be suggested by what has been said above.

Some other effects which have not been previously recorded have been reported to me by F. G. Moses, of the General Engineering Co. He had observed the appearance of the tailing from the flotation machines, treating a sphalerite, when it was passed over a slime-table (as a pilot to indicate the work of the flotation machine by the size of the concentrate streak produced). Before the addition of copper sulphate the slime of the tailing seemed impalpable but afterwards it had the appearance of curdled milk (flocculated). However, in a second mill the slime in the tailing still seemed to be deflocculated. In both instances the finely ground zinc sulphide in the concentrate seemed to be flocculated and in the second case the grade of the concentrate was raised considerably by passing it through a drag classifier from which some of the deflocculated gangue slime could overflow. This observation by a young engineer who kept his eyes open may be of a great deal of importance. I have often noticed the flocculated condition of the concentrate in flotation froths, but had been inclined to attribute it to the oil which supposedly collected the material into small units. Evidently the copper sulphate could assist in this floculation, for it is well known that heavy metal ions are strongly adsorbed. In colloid chemistry it is usual to find very small amounts of such chemicals producing striking effects and it is probable that the extremely small amounts of copper sulphate involved in the case at hand are sufficient only for some colloidal reaction, be that what it may.

The condition of the concentrate and gangue particles, with regard to their degree of floculation, has not been sufficiently investigated and we are hence confronted with the necessity of determining just what becomes of the copper introduced into such ore-pulps. Is it precipitated as copper sulphide or is it adsorbed?

LIME AND ALKALIES

Of late there has been a tendency to use various alkalies as addition agents in flotation, with the result that in many places they are competitors of acid. Of course, the best thing to do, if possible, is to find an oil mixture that will not call for any addition agent, but as

long as the use of these further addition agents increases the extraction of the desired mineral or improves the grade of the concentrates enough to more than pay for the amount of addition agents used, they will not be displaced. The use of alkaline addition agents has advantages in lessening the corrosion of the machinery and often diminishes the amount of oil necessary. With alkaline pulp the oils can be added to the pulp ahead of the final grinding machinery so that the tube or ball-mills can be caused to disseminate the flotation oil before the pulp reaches the flotation machinery.

Few people have reported any observations on the phenomena produced by the use of these additional agents beyond the improvement of the metallurgical results. There is no doubt but that soluble heavy-metal salts are precipitated by the use of these various alkaline substances and it is also well known that these heavy metal compounds are often deleterious to flotation, so that their removal by precipitation is imperative. Whether more than the amount of alkaline agent necessary to react with the deleterious salts should be added is not known. It is known that in a number of instances it has been possible to float a "tarnished" ore by the addition of various alkaline sodium salts where the same flotation oils did very little good when used on the ore alone. If sodium sulphide were the alkali used this would not be surprising as it could be easily seen that the sodium sulphide would react with copper carbonates and other oxidized minerals, forming sulphides and thus causing their flotation. But when sodium hydroxide brings about the same results it makes it seem possible that the thin films of oxidized material are dissolved off of the faces of the natural sulphide particles. This would be possible with zinc, copper or lead ores since the hydrates of these metals are somewhat soluble in sodium alkaline solutions. Instances of improvement of the grade of work with ores containing each of these metals are known. I have not heard of many instances of the improvement of the flotation of pyrite by the use of such addition agents. British patent 5856 of 1914, granted to Minerals Separation and DeBavey's Processes Australia Proprietary, Ltd., states definitely that in the flotation of such tarnished ores the water in the circuit should be distinctly alkaline toward phenolphthalein. Sodium carbonate is the alkali preferred.

The use of caustic soda at a number of mills has resulted in some degree of satisfaction, especially with the porphyry copper ores. At the September, 1916, meeting of the American Institute of Mining Engineers, during the discussion of one of the papers, it developed that the Old Dominion mill at Globe, Arizona, was using caustic soda to the amount of 1 lb. per ton of ore. According to the metallurgist, Mr. Cramer,* this resulted in a much less viscous froth which tended to lay more flatly in the flotation machine and was more easily broken down and ran more easily in the froth launders so that not so much water was required. This, in return, allowed better work in the overworked Dorr thickeners, where the flotation concentrate was thickened before filtering. Further the extraction was somewhat increased, the grade of the concentrate was raised and hence less "insoluble" was left in the concentrate. At still another mill a reduction in the flotation oil necessary also resulted.

*Trans. Am. Inst. Min. Eng., Bull. 119, p. 1891, Nov., 1916.

It is noticed that such alkalies cause a weaker and more mobile froth. The effect of the addition of alkali to a ball of stiff clay lying on a board is well known. A drop of alkali will cause the clay to flatten out whereas the same amount of water does not. The alkali defloculates the clay so that it "liquifies." The cause of the decreased viscosity of the froth in a flotation machine is hence easily understood. The higher extraction of the desirable mineral is also easily explained, because the alkali tends to deflocculate the gangue slimes and therefore any desirable mineral particles intrained in the gangue will be liberated and become available for flotation. As a result of this not so much excess of flotation oil and agitation will be necessary in the attempt to mechanically break up the gangue particles and bring the oil in contact with the sulphide minerals. Not so much air being necessary to bring the mineral particles to the surface there will not be such a large proportion of mechanically intrained gangue in the froth concentrate. In other words, all the effects above noticed can be explained on this assumption.

Of the various alkalies used, caustic soda, sodium silicate, sodium carbonate, sodium sulphides and lime are the principal commercial ones. Sodium silicate is a more powerful deflocculant than sodium hydrate, possibly due to a protective action of the colloidal silicic acid formed in dilute solutions. It was used for a while with success in the flotation plant of the Utah Leasing Co., but was later displaced by sodium carbonate. Our own experience with many different types of minerals, at the Salt Lake station of the Bureau of Mines, has been that sodium carbonate is the most desirable alkali as it does not tend to so permanently deflocculate the gangue slimes, allowing easier thickening and filtration of the flotation concentrate and tailing.

A rather surprising claim is made in U. S. Patent 1,203,341 of Oct. 31, 1916, granted to Allen C. Howard of the Minerals Separation Co. He claims that if alkaline substances are made up into a strong solution and the proper amount dripped into the first cell of a series of flotation machines a better result is obtained than where the circuit water which contains the ore is already alkaline to the same extent. Attempts to check this claim by experimentation in our laboratory have failed to justify it. The patent claims that in the mill of the Caucasus Copper Co., in the Caucasus, Southern Russia, this effect is quite marked. We fail to understand just how this can be so, and think that the patent is actually attempting to claim the use of these alkalies in the manner in which they are most naturally used—in the form of a strong solution, the proper amount of which is dripped into the pulp at the most convenient point in the flow-sheet. To avoid infringing the patent the alkali would have to be previously mixed with all the mill water before the ore was ground in it, which might easily prove more expensive and less easily performed.

Lime is not such a desirable addition agent as the alkaline sodium compounds and while it may cause desirable effects when added in small amounts, an excess is often harmful. Lime and most other calcium compounds are usually flocculators of gangue slime, rather than deflocculators as the alkaline sodium compounds are. This may explain the difference between the two, although it has been continually hinted that we know entirely too little about the condition of flocculation of the ore

pulp during flotation. It is very probable that in the cases noticed where lime improves the flotation it functions in precipitating other less desirable soluble impurities such as iron sulphates. At the Miami mill it was found that if lime were added to the pulp before entering the ball mills a somewhat increased extraction resulted, whereas the addition of lime directly at the head of the flotation cells resulted disastrously. Supposedly the lime had to be allowed time enough to react with all the soluble or semi-soluble impurities of the pulp before going to flotation so that there would be no raw caustic lime to cause trouble.

Sodium sulphide and calcium sulphide or polysulphides are used in the flotation of oxidized ores of lead and copper. Hydrogen sulphide is also in use for the same purpose in the flotation of copper sulphide ores. The oxidized minerals are "sulphidized" by these chemicals and can be floated in the same manner that the natural sulphides can be floated. However, there is no objection to using sodium sulphide or the other sulphides to precipitate soluble heavy metal salts from solution. Hence these soluble sulphides can serve a double function. Three mills are now in operation using sodium sulphide, in the sulphidizing of lead carbonate ores, and several copper mills use it for oxidized copper compounds. The method is fairly satisfactory because only small amounts of the sodium sulphide are used, the lead carbonate particles being merely coated superficially with a film of lead sulphide which can be oiled and floated. As little as 3 lb. sodium sulphide per ton of ore, containing 15 per cent lead, is successful in causing the flotation of over 90 per cent of the lead minerals. In case the ore contains manganese dioxide, basic iron sulphates or lead peroxide minerals these tend to use up the sodium sulphide before the lead carbonate is satisfactorily sulphidized. Since such minerals are fairly common in the oxidized ores of lead the method can be applied to only those ores which are free from such constituents. Hydrogen sulphide is in use in the mill of the Magma Copper Co., at Superior, Arizona, sulphidizing copper carbonates.

Of all the alkaline compounds mentioned above, lime is the cheapest but not the most desirable. Sodium carbonate is not only highly desirable but also can be obtained more cheaply than most of the other sodium compounds. In fact most of the flotation work which calls for the use of sodium carbonate is situated in the intermountain region not far distant from the alkaline lakes and natural trona deposits of the arid and semi-arid regions. An outlet for the sale of this crude natural soda has long been desired. At the present time most of the soda in use by flotation mills is shipped in from the east and is much purer and more expensive than the work demands.

Sodium sulphide also costs too much when delivered into the intermountain country from the middle west or the east. It can be made from niter cake or from sodium sulphate by reduction. Sodium sulphate is available in a fair degree of purity from deposits on the bottom of Great Salt Lake or from Searles Lake in California.

ORGANIC ACIDS

Organic acids, like tartaric acid, citric acid, etc., and their salts, have been mentioned in British Patent 17,327 of 1914, granted to Geo. A. Chapman, one of the

Minerals Separation engineers. Argols, the crude tartrate of potassium, was added to the pulp in both the Anaconda, Montana, and the Burro Mountain, New Mexico, mills which are treating copper ores. The argols were introduced into the pulp as it entered the tube mills, in amounts ranging from one-tenth to one-fourth of a pound per ton of ore. Both of the ores mentioned are noted for the high percentage of colloids present, due to clay-like minerals in the original ore. The flotation results were said to be greatly improved. The effect of the tartaric acid seems to be a slow flocculation or coagulation of the gangue slime.

These organic acids and their salts are known to have low dissociation constants, and the theory advanced in Chapman's patent is that these reagents do not flocculate the gangue slime so quickly but that the sulphide minerals escape entrainment in the flocs so that they are collected by the oil and air into the froth before flocculation of the gangue. To quote the words of the patent, "The effect of electrolytes upon colloids (as is known) depends *inter alia* upon the valency and upon the ionizing power or dissociation constant of the electrolyte. Tartaric acid is divalent and as compared to ordinary mineral acids it has a low dissociation constant. Citric acid has similar properties but is trivalent.

Many other electrolytes such as organic acids and their salts also have similar properties as electrolytes and the choice of a suitable electrolyte for the purposes of this invention can be readily determined by a preliminary test.

This is a most interesting theory but I have noticed that citric acid, which is mentioned above, usually does not flocculate gangue slimes but rather exerts the reverse effect. It is probable that the effects of organic acids in flotation will be found to be as erratic as their absorption effects commonly known to colloid chemists.

SILICOFLUORIDES

British Patent 4938 of 1914, granted to Sulman and Minerals Separation, calls for the use of silicofluorides as a substitute for acid in the flotation of ores. It is claimed that these compounds give the desired results. The complex fluorine salts have rather unusual ionization and other chemical constants, and hence it might easily happen that the effects on flotation would be unusual and hard to predict. The diversity of the various compounds mentioned as having been patented by the Minerals Separation Co. shows how far their engineers and chemists have gone in developing the process of flotation.

A test of Broken Hill (Australia) tailing was made in London tap water without the addition of potassium fluoride and another test was made with this addition agent present to the extent of 3.4 lb. per ton of ore. The oil used in each test amounted to 2.0 lb. of eucalyptus oil per ton of ore. The data on the two tests were as follows:

	Ordinary Flotation	With Silicofluorides
Heading	Zinc 19.0%	Zinc 19.0%
	Lead 7.0%	Lead 7.0%
Concentrate	Zinc 29.0%	Zinc 36.1%
	Lead 9.3%	Lead 14.7%
Tailing	Zinc 14.4%	Zinc 4.8%
	Lead 2.5%	Lead 1.6%
Recovery	Zinc 56.0%	Zinc 86.2%
	Lead 70.2%	Lead 88.5%

The patent also makes a good suggestion that the silico-fluorides can be prepared by adding hydroflu-

oric acid to the ore pulp. This produces soluble silico-fluorides of the bases in the pulp. The main value of a substitute for sulphuric acid would be for ores containing a great deal of calcium carbonate or other acid-consuming materials in the gangue.

CALCIUM SULPHATE

Copper sulphate has been added to ores containing colloidal gangue, although its success has been somewhat erratic. It was once used in one of the Broken Hill mills and its effect was that of an electrolyte. It is very sparingly soluble so that there can never be a high concentration of its ions in solution, and it is hence more or less equivalent to the tartrates in providing ions rather slowly so that supposedly the flocculation of the gangue slime will not intrain particles of the desired mineral.

SODIUM MANGANATE AND SODIUM CHROMATE

These are two oxidizers recommended for differential flotation of two flotative minerals. They seem to deaden one on the other of the flotative minerals so that it will not float. The exact mechanism of this deadening action is not known for while chromates will deaden galena particles in the presence of sphalerite, manganese compounds have the reverse effect. They are very efficient in this type of work but there is a widespread impression among metallurgical men that they are too expensive. To be sure, the market prices on the chemicals usually sold are rather high but high purity of these compounds is not essential. There is no apparent reason why they should not be made by fusing local manganese or chromium ores with sodium carbonate. Manganese ores are usually easily available in most zinc and lead districts although the chromium ores are harder to obtain. Mill managers who have considered only potassium permanganate of the usual high commercial purity might well give their attention to the more cheaply prepared and equally useful sodium manganate.

SULPHUR DIOXIDE, SODIUM SULPHITE, SODIUM THIO-SULPHATE

These reagents are inhibitors of flotation, if used in sufficient amounts. If sulphur dioxide is applied to an ore pulp the first effect is one similar to that obtained when sulphuric acid is added to the pulp—an improvement in the flotation. However, if the sulphurous acid is allowed to act on the ore long enough to form sulphites the result will be non-selective flotation and the gangue will be floated with the desired mineral particles. The great use of such compounds has been found in differential flotation, the basic idea being to add just enough of one of these inhibitors to deaden the surfaces of one kind of flotative minerals while another group is only slightly affected and can still be floated. Mixtures of sphalerite, galena, pyrite and chalcopryrite or any two of them, usually need separation and in case they need to be finely ground to be liberated from each other mechanically differential flotation methods are in demand.

CHLORIDE OF LIME

Chloride of lime is said to be very good for differential flotation of sphalerite in the presence of pyrite.

SODIUM CYANIDE

In most cyanide mills which have tested their tailing by flotation it has been found that the cyanide left in the tailing is deleterious to flotation. E. J. Atchison has informed us that in some tests made by him with the ore of the Amparo Mining Company, of Mexico, this effect was noticed unless the amount of cyanide present was less than 0.007 per cent on the weight of the ore or 0.0018 per cent in the mill water, under which conditions improved flotation results were obtained over what could be done in water containing no cyanide.

At the mill of the Ohio Copper Company, Lark, Utah, mine water containing a rather high percentage of the sulphates of iron and similar impurities is used in the flotation and the addition of a small amount of cyanide has been found to greatly improve the flotation.

It is probable that in both these instances complex double cyanides are formed with the solutes in the mill water and it may even be that some of the most undesirable are precipitated by the cyanide. So far as we know very little has been done in the study of the cyanogen compounds for flotation.

CONCLUSION

The use of certain chemicals in the flotation concentration of ores has been described and theories of the action of these chemicals have been explained. The use of chemical addition agents in ore-pulps during flotation is only in its infancy, and as the process is better understood operators will make greater use of chemical addition agents which will allow them to obtain the highest economic results. The possibilities of such applications are almost unlimited and it is probably along lines of this kind that some of the great advances in ore flotation will be made.

Flotation of Chalcopyrite in Chalcopyrite-Pyrrhotite Ores of Southern Oregon*

BY WILL H. COGHILL

INTRODUCTION

In 1916 the Federal Bureau of Mines entered into a co-operative agreement with the Oregon Bureau of Mines and Geology for the purpose of investigating problems bearing on the treatment of low-grade and complex ores. The writer, as consulting metallurgist, was placed in charge of these investigations, and laboratory room for the necessary tests and experiments was provided at the Oregon Agricultural College, at Corvallis. One of the first problems taken up was the possibility of separating chalcopyrite from pyrrhotite and pyrite by flotation.

Chalcopyrite is the copper-bearing mineral at many places in southern Oregon; often it is intimately associated with pyrrhotite and pyrite. In places these two gangue minerals form as much as 75 per cent of the ore, so that the vein is almost wholly sulphides.

Gravitation methods of concentrating the copper-bearing mineral cannot be applied because the gangue sulphides have practically the same density as chalcopyrite. Magnetic separation does not seem practicable—assuming that the gangue sulphides can be made to respond naturally or by a preliminary treatment to an electromagnet—because fine grinding is re-

quired to liberate the mineral grains. The methods of concentration now in vogue are hand-sorting and jigging, which eliminate some of the siliceous gangue. An inspection of the smelter returns in the possession of mine operators gives the impression that the average grade of ore shipped runs 10 per cent copper.

The experiments on separating the chalcopyrite from the gangue by flotation have been carried through the preliminary laboratory stage with flattering results. As a mill is never considered complete and finished until the ore-body is exhausted and the mill has served its purpose, so in this and in other ore-testing experiments there are still undetermined factors. However, in order that those who are interested in the separation of sulphides by flotation may have the results of the laboratory work before them, this preliminary report is published by the Bureau of Mines.

TESTS AND GENERAL DISCUSSION

The tabulated data in Table I show the results of what might be called progress tests or those in which the results were similar to those of successful practice. Many random tests were made to find the nature of disturbing influences and how to meet them, but only a few of these are mentioned.

TABLE I—RESULTS OF PROGRESS TESTS
(Samples used weighed 1 to 16 pounds and carried 1.13 per cent to 3.2 per cent copper; ratio of concentration from 8 into 1 to 12 into 1.)

No.	Name of Mine	Through 200-Mesh, per Cent	GRADE OF TAILINGS	
			Per Cent Copper in Tailings	Per Cent Copper, in Tailings of Total Copper in Ore
1	Waldo	54.0	0.45	7.2
2	Waldo	74.6	0.70	20.7
3	Waldo	94.0	0.30	6.1
4	Waldo	92.0	0.50	13.0
5	Morrison	44.0	0.12	6.3
6	Morrison	97.7	0.12	5.0
7	Rowley	82.0	0.25	8.6
8	Rowley	82.2	0.20	6.2
9	Queen of Bronze	64.5	0.55	...
10	Queen of Bronze	64.5	0.30	23.4
11	Queen of Bronze	64.5	0.26	16.7
12	Queen of Bronze	64.5	0.23	8.1
13	Queen of Bronze	95.5	0.55	24.5
14	Queen of Bronze	94.5	0.50	20.3
15	Queen of Bronze	91.4	0.35	15.1
16	Queen of Bronze	92.0	0.90	29.2
17	Queen of Bronze	77.5	0.70	16.6
18	Queen of Bronze	99.0	0.60	16.1

All the samples were fresh and unoxidized except Nos. 16, 17 and 18. These three contained some malachite and azurite; this accounts for the tailings being higher grade than the average.

Several of the progress tests were made to conform to the tentative flow sheet (Fig. 1). The results of one

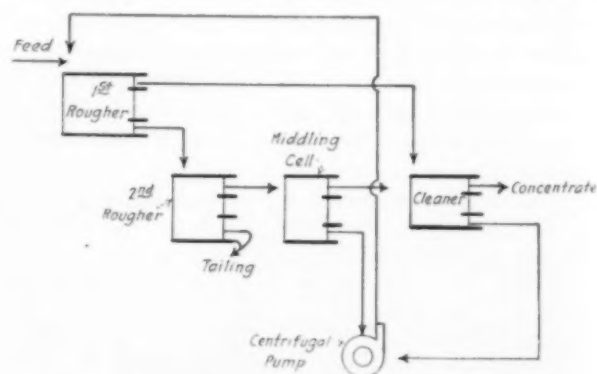


FIG. 1. TENTATIVE FLOW SHEET FOR CHALCOPYRITE-PYRRHOTITE ORES OF SOUTHERN OREGON.

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which was made in co-operation with D. C. Morris, representing the American Exploration Co. of Grants Pass, are given in Table 2. This sample was crushed excessively fine. It is likely that a fineness of 75 per cent through 200-mesh would have been satisfactory. Callow cells were used, but the Minerals Separation type of machines seemed to give equally good results.

TABLE II—PRODUCTS OF FLOTATION TEST OF QUEEN OF BRONZE ORE IN CALLOW CELLS

(Feed assayed 3.0 per cent Cu.; sample crushed to 99 per cent through 200-mesh; contained oxidized copper.)

No.	Products	Weight of Product, Grams	Percentage of Total Weight	Copper in Product, per Cent	Grams of Copper on 100-Gram Basis	Per Cent of Total Copper
54	Concentrate.....	450	6.0	28.3	1.70	58.5
63	Tailing from middling cell.....	925	12.3	3.3	.41	14.1
65	Tailing from cleaner.....	227	3.0	11.0	.33	11.3
61	Tailing.....	5940	78.7	0.6	.47	16.1
		7542*	100.0	2.91	100.0

*7542 grams—16.6 lb.

As the work was done with the intermittent type of machines, there were necessarily middling products—63 and 65 in Table II—that have to be disposed of by approximation, as shown below:

METHOD OF APPROXIMATING RESULTS

From Table II, the milled products would appear, on a 100-gram basis, to be about as follows:

Percentage of Recovery.—Nos. 63 and 65 containing $12.3+3.0=15.3$ grams of pulp would produce a tailing running 1 per cent copper.

(a) Then $15.3 \times .01 = .15$ grams copper lost.

This loss added to that from No. 61 shows a total of $.15+.47=.62$ grams copper lost, or $.62 \div 2.91 = 21.3$ per cent of the total copper is lost. Hence the recovery is 78.7 per cent.

Ratio of Concentration.—These two middling products contain $.41+.33=.74$ grams copper.

By (a) .15 grams is lost.

(b) The recovery from them is, therefore, $.74-.15=.59$ grams copper.

(c) Assume that this .59 grams of copper is in a concentrate running 25 per cent copper. There would be, therefore, $.59 \times 4 = 2.36$ grams of concentrate.

(d) The total concentrate would then amount to 6.0 (No. 54) $+ 2.36(c) = 8.36$ grams concentrate.

This means a final concentration of 100 into 8.36 or 12 into 1.

Grade of Concentrate.—8.36 grams (d) concentrate contains:

$1.70(\text{No. 54}) + .59(b) = 2.29$ grams of copper;

$2.29 \div 8.36 = 27.4$ per cent copper in concentrate.

COMMENT ON METHOD

This method of approximation applied to the tests from samples 1 to 15, inclusive (Table I), which show an extraction of 90 per cent with an equally high grade concentrate, except where, as shown by grab samples of the overflow, the test was stopped too soon. The reader should note in regard to the tests shown in Table II that only 15.3 per cent of the charge entered the closed circuit for retreatment. This quantity although small when compared with average practice is excessive for these ores; it was great in these tests because the tests were prolonged in the effort to float the oxidized cop-

per. The freedom with which the fresh chalcopryite floats is remarkable. At times there is also a striking play of brassy colors on the overflow.

COLOR NOT A TRUE INDICATOR OF GRADE OF FROTH

This reference to color introduces a fertile subject for scientific discussion but it must be treated briefly here. The first impression was that the color was a true indicator of the grade of the froth, but later work showed that it was not. Sometimes the Minerals Separation type of machine gave a richer looking froth than the Callow type, when analysis showed it to be of lower grade. When the pulps are of equal densities, the Minerals Separation machine gives, without fail, a brassier froth than the Callow. This seems natural because the Minerals Separation machine makes less froth where the bubbles have had more opportunity to gather the chalcopryite. The burden of chalcopryite is, therefore, heavier and more evident than in a Callow machine where the great number of bubbles—some of them doubtless barren—dart to the surface and form a voluminous froth. The heavy burden of non-wetted mineral carried by the froth stabilizes it by the "screw-back" effect that the author has discussed in a recent paper.¹

The Callow froth showed a better color on the concave upward surface than on the convex, i. e., in the depressions. Although it is true that the weight of the mineral grains should be considered as a factor in causing them to slip down the surface to the lowest point and thus increase the burden there, the reader should note also that the resultant of the molecular forces points in that direction. The non-wetted mineral particles (on the upper surface) would, therefore, be expected to slip down the "meniscus" while the tendency of molecular forces would be to pull the wetted mineral particles to the highest points, resulting in segregation. The relation of the component forces has been outlined in a paper in the Colorado School of Mines Magazine.²

GOLD RECOVERY

The ores assay about \$2 a ton in gold. Hand-sorting a Queen of Bronze sample and assaying revealed that about 95 per cent of this gold is in the chalcopryite. Unfortunately the flotation concentrate contains too small a proportion of the gold. It is likely that the gold is embedded in the cleavage planes of the chalcopryite and is released on crushing. The gold in the tailings amalgamated freely in bottle-amalgamation tests, proving it to be in the metallic state.

Only one oil was tried. It was selected from a stock of twenty-two oils on account of its desirable physical properties. The surface tension effect of these oils had been determined and plotted by E. H. Miller of the Bureau of Mines, and the one used was found to give a steeper surface tension curve than any other oil in stock. This was desirable because it was thought that a froth with a slightly variable surface tension would, with the solids present, be sufficiently stable. Whether the other oils would have proved satisfactory was not determined but the oil mentioned gave excellent results. Its miscibility is an important characteristic.

Only once, and then by accident, was the ore ground

¹Rickard, T. A., and Ralston, O. C., Flotation, p. 195 (1917).

²Coghill, Will. Natural Laws in Flotation, Colorado School of Mines Magazine, Vol. 7, 1917, p. 1.

in the presence of an insoluble oil. The insoluble oil acted as a collector on all the sulphides present and spoiled the differential separation sought. The overflow carried only 5 per cent copper whereas 30 per cent copper in the first overflow was desirable and expected when the pulp carries $2\frac{1}{2}$ per cent.

As already stated, the oil used reduces surface tension. It seems strange, in view of all that has been written about surface tension, that there are no published data on absolute values of surface tension of mill solutions. In the course of these experiments several determinations were made by the drop-weight method. One determination gave: Surface tension of overflow 65.9 of underflow, 69.8. This result is in accord with tests made to prove absorption, as given in textbooks on colloid chemistry. The quantity of oil necessary is minute, one-tenth of a pound per ton of ore being ample. The oil was added to the charge in the cell, and the overflow could be drawn after an interval of a few seconds. Neutral water was used.

PRECAUTIONS TO BE OBSERVED IN USING PROCESS

The process is simple when two "Don'ts" are observed.

Don't grind in the presence of an insoluble oil; use it cautiously in any event.

Don't grind samples in a disk pulverizer, and if the use of a ball-mill instead of a pebble-mill is contemplated, make careful tests to see whether the iron surfaces of the balls have an injurious effect. This is especially interesting in connection with the statements of Zachert* and Gahl† showing that the use of iron balls has a beneficial effect.

In the experiments described in this paper no apparatus was available for determining the effect of grinding with iron balls in a ball-mill, but it was proved conclusively that, for the flow-sheet used, the use of the disk pulverizer is not only objectionable but should be avoided for either wet or dry crushing. The same conclusion applies to a "made-up" ore containing chalcopyrite. Two comparative runs were made. Each sample consisted of pulp that had been prepared for cyanide tests, and 30 grams of chalcopyrite. The copper mineral in one was prepared in the disk machine, in the other it was ground to the same degree of fineness in a porcelain mortar. Table III shows the relative floatability. The mineral prepared in the mortar overflowed much more freely and gave a higher grade product.

TABLE III—RESULTS OF DISK AND MORTAR GRINDING

Prepared in	Grains—Overflow	COPPER IN OVERFLOW	
		Per Cent	Grams
Disk.....	10	14.0	1.4
Mortar.....	24	16.2	3.9

These results show that the disk pulverizer should not be used until proved harmless.

Exports of Mineral Oils Show Big Increases.—

More mineral oils were exported from the United States during the fiscal year 1917 than ever before, the total amounting to 2,749,438 gallons valued at \$230,953,149, according to figures made public by the Bureau of Foreign and Domestic Commerce. This was an increase of approximately 300,000,000 gallons over 1916.

*Zachert, Victor, Beneficial Effect of Grinding with Steel Balls in Flotation; *Min. and Met. Eng.*, Vol. 114, May 12, 1917, p. 663.
†Gahl, Rudolf, History of the Flotation Process at Inspiration, *Bull. Am. Inst. Min. Eng.*, No. 117, Sept., 1916, p. 1656.

Laboratory Methods* for Benzol-Recovery Plant Operation

By F. W. Sperr, Jr.

Chief Chemist, H. Koppers Co.

The importance of the benzol industry to the cause of National Defense has achieved general recognition during the last three eventful years. The recovery and rational utilization of as large amounts as possible of benzene and toluene, which are so important in the manufacture of explosives, must be considered a national necessity. There are two indispensable steps in securing the most efficient conservation of our benzol resources, namely:

1. The installation of the most efficient type of benzol-recovery plant wherever sufficient benzol is being produced to warrant recovery.

2. Careful control of the operation of each plant so as to reduce losses to a minimum.

The second step involves the use of correct laboratory methods for the testing and analysis of the various materials and products. The importance of this phase of the industry must be highly emphasized, and in view of this the writer has obtained the consent of the H. Koppers Company to publish some of the laboratory methods that it has found valuable. These cover all of the ordinary requirements of the benzol plant operator and chemist, for whose assistance, principally, the somewhat detailed descriptions have been written.

In studying the methods from an operating standpoint, it will be of assistance to the reader to review briefly the method of operation of the benzol-recovery plant. The Koppers system, which is the most generally used in America, is shown on the accompanying diagram, Plate A.

The gas is brought to the proper temperature in the cooler *a*, and then passes into the washer *c*, where it is treated with an absorbent oil which scrubs out all of the benzols. The enriched wash-oil is pumped from the scrubbers to heat exchangers *e* and *f*, which are heated by the benzol vapors and by the hot debenzolized wash-

*Copyrighted, 1917, by the H. Koppers Co. Contributed by the Laboratories of the H. Koppers Co., Mellon Institute, Pittsburgh, Pa.



THE FIRST PLANT IN THE WORLD FOR THE RECOVERY OF TOLUENE FROM CARBURETTED WATER GAS

Built by the H. Koppers Company early in 1916. This plant has a capacity for recovering toluene from ten million cubic feet of gas per day.

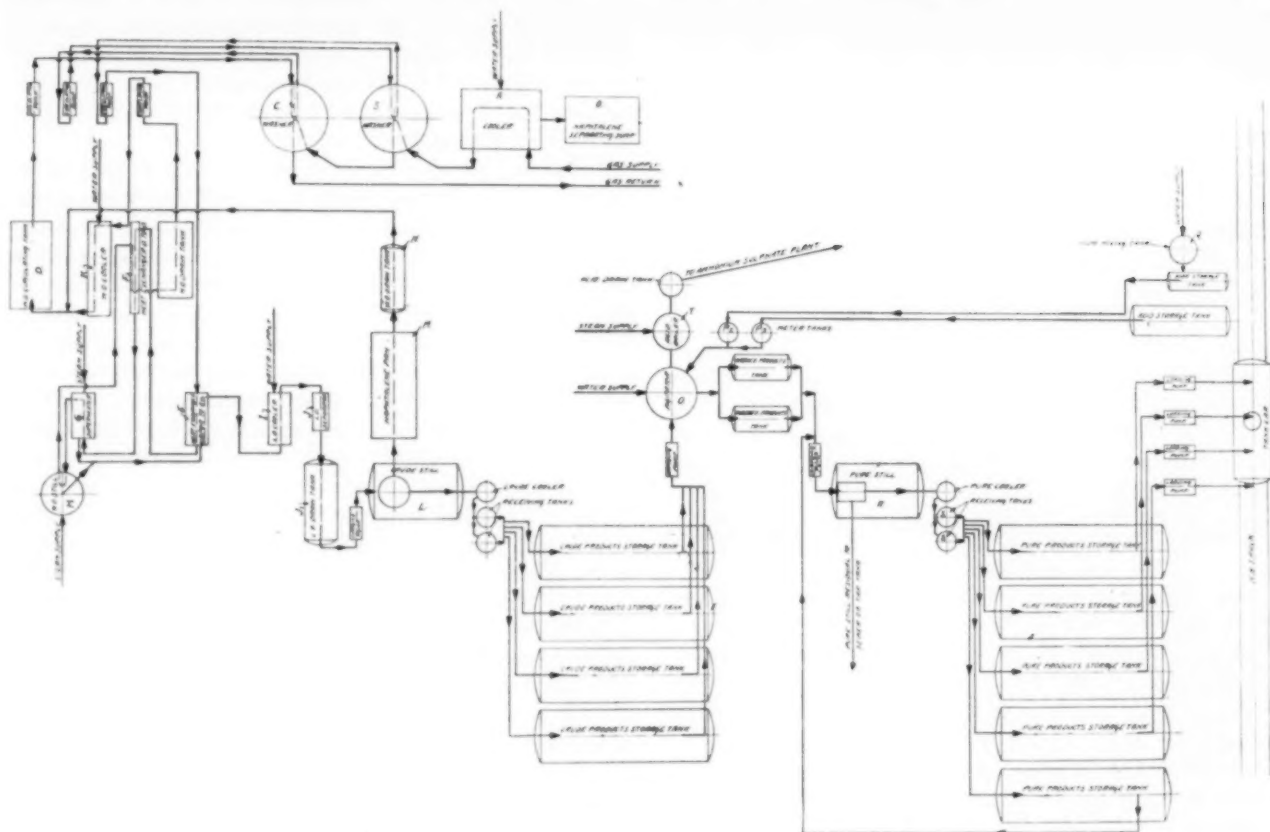


PLATE A. DIAGRAM OF KOPPERS SYSTEM OF BENZOL RECOVERY

oil respectively. It is then still further heated to the maximum temperature desired by means of live steam in the superheater *g*, from which it passes into the still *h*. In this still the benzols are entirely expelled in the form of vapor. This hot vapor gives up part of its heat to the incoming wash-oil in the heat exchanger *e*, and then is condensed and separated from water in cooler *i* and separator *j*. The hot wash-oil leaving the bottom of the still passes through heat exchanger *f*, where it gives up part of its heat to the incoming wash-oil, and then is finally cooled in water cooler *k*. The cool oil is delivered to circulating tank *d*, from which it is pumped back again over the scrubbers; thus completing the cycle. The light oil is distilled in crude still *l* and the various fractions are purified by treatment with acid and soda in agitator *o*, and rectification in the pure still *r*.

Practically every by-product coke plant in America is now equipped with benzol-recovery apparatus, but the total product does not satisfy the ever increasing demand. To augment the supply of the important benzols—particularly toluene—we still have recourse to the large quantities of water gas that are manufactured for domestic purposes throughout the country. The H. Koppers Company was the first to undertake the large scale recovery of benzol from water gas. Plants built by this company are now treating nearly 2,000,000,000 cu. ft. of gas per month, and are producing nearly 1,000,000 gal. of crude light oil per month. Additional plants, now under construction, will soon largely increase this rate of production. In most cases, the toluene, which is so important for military purposes, is the only important substance separated from the light oil; the other benzol homologues being

returned to the gas to satisfy requirements for candle-power and calorific value.

The routine tests usually required in the operation of a benzol-recovery plant completely equipped for the production of pure benzene and toluene may be classified as follows:

A. Tests of Gas:

1. Determination of light oil in gas entering scrubbers.
2. Determination of light oil in gas leaving scrubbers.

B. Tests for Wash Oil Still Operation:

1. Determination of light oil in benzolized wash-oil.
2. Determination of light oil in debenzolized wash-oil.

3. Tests of the light oil:

- a. Boiling point.
- b. Determination of wash-oil.

C. Tests for Crude Still Operation:

1. Receiver tests; i.e., boiling point tests made to control fractionation.
2. Boiling point tests of fractions (crude benzol, crude toluol, etc.) and residues sampled from their respective storage tanks.

D. Tests for Agitator Operation:

1. Distillation and acid tests of washed benzols.
2. Tests for SO_2 in washed benzols.
3. Specific gravity of regenerated sulphuric acid.

E. Tests for Pure Still Operation:

1. Receiver tests; i.e., boiling point tests made to control fractionation:
 - a. Boiling point.
 - b. Acid test.

2. Tests of pure products sampled from storage or running tanks or from shipments.
 - a. Boiling point.
 - b. Acid test.
 - c. Specific gravity.
 - d. Freezing point (occasional in case of benzene).
 3. Boiling point tests of still residues.
- F. Tests of Materials used in Operation:
1. Wash-oil:
 - a. Specific gravity.
 - b. Viscosity.
 - c. Emulsification.
 - d. Cold test.
 - e. Distillation.
 - f. Olefines.
 2. Sulphuric acid—Specific gravity.
 3. Soda— Na_2O .

Method for the Determination of Light Oil in Gas

APPARATUS

- 1½-in. steam-jacketed sampling pipe with valve (Fig. 1).
 - 11 reagent bottles, 16-oz., narrow neck, with rubber stoppers.
 - 1 wet gas test meter reading to 0.001 cu. ft. with the thermometer.
 - 1 steam distilling apparatus, 1 gallon capacity.
 - 2 Liebig condensers—15 inches.
 - 1 separatory funnel—300 c.c.
 - 1 special distilling flash—200 c.c.
 - 1 measuring tube 50 c.c. graduated in 1/10th c.c.
 - 1 thermometer—200 deg. C.
 - 1 Hempel dephlegmating column (Fig. 2).
- Burners, supports, and tubing, to complete apparatus as described below.

The method consists of three steps, viz.:

1. Extraction of the light oil with wash-oil.
2. Steam distillation of the benzolized wash-oil.
3. Dry distillation of the separated light oil.

The wash-oil must be a petroleum product corresponding to specifications that will be published later in this series of articles.

Referring to Fig. 1, *B* is a ½-in. sampling pipe inserted in the gas main (*A*). The end in the center of the main is bent in the direction of the flow of the gas. In case the gas contains much naphthalene, provision must be made to heat a portion of the sampling tube where it emerges from the gas main. This may be accomplished as shown in the figure by means of a steam jacket about 20 in. long and 2 in. in diameter. When the naphthalene is in large quantity, causing stoppage, it may be necessary to keep the first two or three bottles of the absorbing train immersed in warm water, and to wrap all connections with asbestos or flannel.

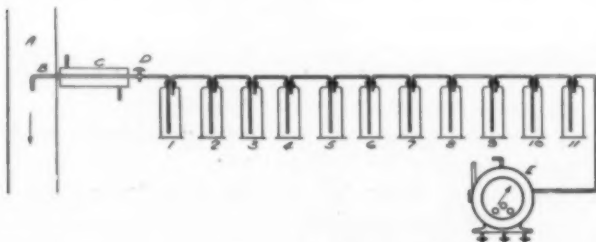


FIG. 1—ABSORPTION APPARATUS FOR LIGHT OIL IN GAS

The flow of the gas is controlled by means of the valve (*D*). The ends of the rubber stoppers that would be exposed to the gas are covered with a little sodium silicate solution just previous to each test. If this precaution is not taken the rubber will absorb appreciable quantities of benzol.

Bottle No. 1 contains about 100 c.c. sodium hydroxide (1 part NaOH to two parts H_2O). Each of the other ten bottles contains about 150 c.c. wash-oil. Rubber tubing is used to connect up the train, but the ends of the glass tubes must be brought closely together so that as little as possible of the rubber may be exposed to the gas. The wash oil must be maintained at a temperature not to exceed 20 deg. C. throughout the test. If necessary, the bottles must be placed in a trough through which cold water is circulated, or else the water may be kept sufficiently cold by adding pieces of ice from time to time.

The gas passing from the train is measured by means of the wet test meter, which must be provided with a thermometer, so that readings may be taken for temperature correction. As a rule this type of meter is not suitable for measuring over 100 cu. ft. of gas, and when gas containing very small amounts of light oil is tested, it is advisable to use a somewhat less sensitive meter of larger capacity. The water in the meter should in all cases be saturated with the gas, and should be at the proper level.

Having connected up the train as shown, heat the sampling tube and let the gas blow out of the valve *D* until the tube is well cleared. Then connect bottle No. 1 with the valve, turn on the gas and inspect the train carefully for leaks. It is usually necessary to have the stoppers securely wired down. Now adjust the rate of flow. Note and record the meter temperature and the barometric pressure every hour during the test and adjust the rate of flow as often as may be necessary.

The amount of gas to be scrubbed depends on its light-oil content. When testing gas before the benzol scrubbers it is best to regulate the gas volume so that not more than 35 or less than 20 c.c. of light oil will be obtained. In the case of debenzolized gas sampled after passing the scrubbers, it is necessary to take about 100 cu. ft. in 24 hours.

When the required volume of gas has passed through the apparatus, close the valve *D* and disconnect the individual bottles of the train. Pour the wash oil into the copper still of the steam distillation apparatus and rinse each bottle and dip tube with a little fresh wash oil, pouring the rinsings also into the same still. The train may now be filled and connected up for the next test.

STEAM DISTILLATION

Part of the apparatus for this process is shown in Fig. 2. *A* is a copper still of one gallon capacity fitted with a screw cap through which pass the inlet tube for the steam, the exit tube to the dephlegmating column, and the thermometer *C*. The thermometer bulb must dip below the surface of the wash oil and the 180 deg. mark must be visible outside the still. The dephlegmating column is of brass, and is preferably wrapped in asbestos to prevent undue condensation. Dimensions for this are given on the drawing; the bead column is about six inches long. The inlet tube *B* is connected with a suitable source of dry steam by means of a short piece of rubber tubing. In default of a regular supply

of boiler steam an ordinary one-gallon can, fitted with the usual rubber stopper, safety tube and exit tube, and heated by means of a large burner, makes a very satisfactory steam generator. The neck of the dephlegmating column, which has been bent over, is connected with a 15-in. Liebig condenser (E). The lower end of the condenser tube passes into a 300-c.c. separatory funnel. Corks must be used for all connections that will be exposed to light-oil vapors. The separatory funnel is wrapped with a cotton cloth and the outlet tube of the condenser is arranged so that cold water will run over this cloth and keep it thoroughly drenched. A small piece of cotton wool is placed in the mouth of the separatory funnel and around the end of the condenser to prevent currents of air causing undue loss. The separatory funnel is graduated by putting in 25 c.c. of water, marking the level, and then adding 100 c.c. more and marking again.

Place a burner under the copper still and heat until the thermometer shows a temperature of 180 deg. Now turn on the steam and adjust the burner so that the temperature does not exceed 180 deg. nor fall below 170 deg. Water and oil will collect in the separatory funnel. When the water level reaches the 125-c.c. mark, run out 100 c.c. Repeat this until 500 c.c. have been run out, at which point the distillation may be considered complete. Shut off the steam and gas and re-

move the separatory funnel from its support. Run the remainder of the water out carefully. Add to the contents of the funnel 10 to 20 c.c. of a saturated solution of calcium chloride and shake well. Let stand until clear and then run off the calcium chloride solution. Wipe the outlet tube of the funnel dry with a little cotton.

DRY DISTILLATION

Run the dried oil from the funnel into the special distilling flask (Fig. 3) fitted with a cork stopper and thermometer, with a 5½-in. column of 6-mm. glass beads, and connected with a 15-in. Liebig condenser. The condenser is supported vertically and a 50-c.c. measuring tube is placed so as to catch the distillate. Heat the contents of the distilling flask with a small flame, until the vapor temperature reaches 200 deg. C. Allow the condenser to drain a few minutes, then read the volume of oil distilled, correcting for water if present.

CALCULATIONS

Average the barometric pressures and the meter temperatures for the period of the test. Correct the observed gas volume to 760 mm. pressure and 15 deg. C. with the aid of the usual formulæ or tables.

A = corrected gas volume.

B = cubic centimeters light oil obtained.

Then: Gallons light oil per 1000 cu. ft. gas = $\frac{0.264 \times B}{A}$

It will be noted that the result is not expressed as the light-oil content of the original gas, but refers to the gas as measured after the process of extraction. This is in accordance with operating conditions, since as a rule the gas is metered after passing the benzol scrubbers. It is hardly worth while making correction for CO₂ and H₂S removed by the sodium hydroxide in the test apparatus except in cases where these two constituents may be unusually high.

NOTES

(1) The number of bottles in the absorbing train has been worked out by experiment and cannot be reduced without risk of a loss of light oil.

(2) An automatic siphon arrangement may be used for running off the water from the steam distillation, dispensing with watching the separatory funnel. The volume of water in this case should not be reduced much below 75 c.c.

The Analysis of Light Oil

The following method was devised for the purpose of estimating the percentage of benzene, toluene, and solvent naphtha in the light oil obtained in connection with the previously described method for

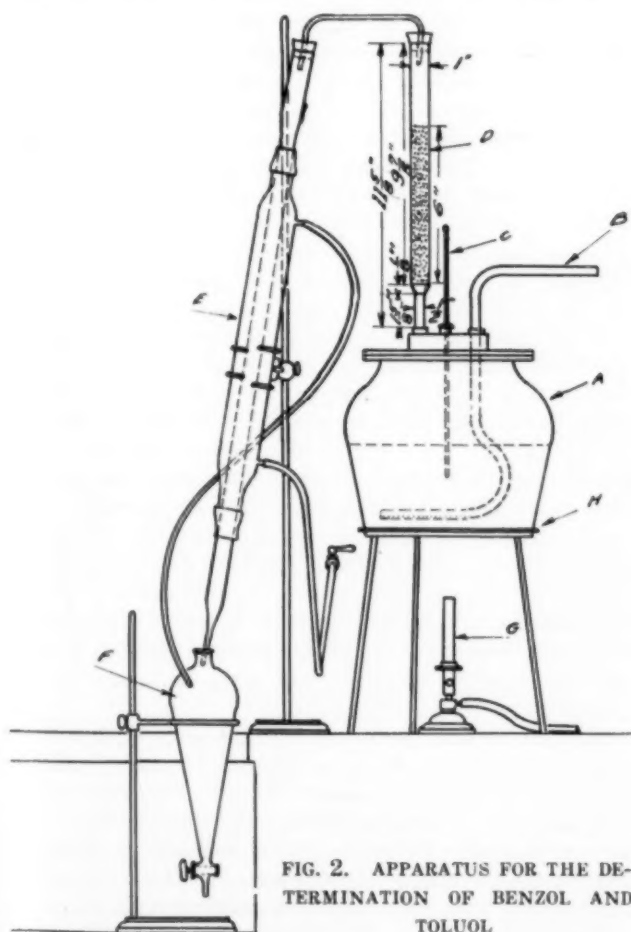


FIG. 2. APPARATUS FOR THE DETERMINATION OF BENZOL AND TOLUOL

- A—Copper Kettle.
- B—Steam Inlet.
- C—Thermometer.
- D—Brass Dephlegmating Column Filled.
- E—15-in. Condenser (with 8-m.m. Glass Beads).
- F—Separatory Funnel 300 c.c.
- G—Bunsen Burner.
- H—Asbestos Board.

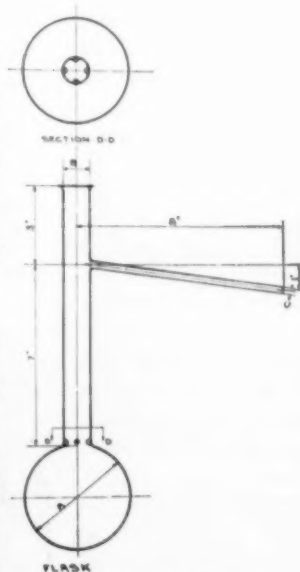


FIG. 3. FLASK

the Determination of Light Oil in Gas (see first page).

Ordinarily the light oil produced from two or three tests may be combined for each analysis. The method has been employed for some time and has given good results for the usual run of light-oil samples, which generally contain at least 50 per cent benzene, and not over 30 per cent toluene. The accuracy of the method is much less for light oil containing less benzene or more toluene, but such material is not so often encountered. If necessary, the simple expedient can be adopted of adding sufficient pure benzene to bring the composition of the sample within the proper limits. Such check determinations as we have made on samples of known composition show that, with careful attention to details, the amounts of benzene, toluene and solvent naphtha can be determined, with an error in each case amounting to about 1 per cent of the total light oil, which is satisfactory enough for ordinary purposes.

PURIFICATION OF THE LIGHT OIL

A sufficient quantity of the light oil is measured from a burette and distilled to 200 deg. C., using a flask fitted with a Hempel column, containing 5 or 6 in. of glass beads. In the testing of samples produced in connection with the determination of light oil in gases this preliminary distillation is made as part of such determination, and need not be repeated. It may be omitted in other cases at the discretion of the chemist. The distillate is caught in a suitable burette and measured. A quantity—preferably about 100 c.c., and in any case not less than 50 c.c.—is drawn off into a slender 300-c.c. separatory funnel, and treated with 6 per cent of its volume of concentrated sulphuric acid (sp. gr. 1.84). This treatment is in two stages.

First, two-thirds of the sulphuric acid is added, then one-third. After each addition of the acid the mixture is shaken about five minutes, allowed to stand until separation is complete (about 15 minutes) and the sludge drawn off. The light oil is now washed with lukewarm water (about 40 deg. C.) and this is carefully drawn off. Then 5 per cent of its volume of sodium hydroxide solution (sp. gr. 1.107) is added; the mixture shaken for 5 minutes, allowed to settle about 15 min-

utes or until clear, and the alkali solution carefully drawn off. Finally the oil is washed with warm water (about 40 deg. C.) and this is drawn off.

Most of the water is removed by washing with 15 to 20 c.c. of saturated calcium chloride solution. After this has been drawn off a little solid CaCl_2 is added and the mixture allowed to stand over night. The light oil is then decanted back into the burette and measured. The difference in volume gives an indication of the practical loss to be expected by sulphuric acid purification on a large scale. The specific gravity of the washed light-oil is determined (at 15 deg. C.), using a pyknometer or Westphal balance.

METHOD OF FRACTIONATION

The distilling apparatus is shown in Fig. 4. The thermometer used is an ordinary thermometer graduated in single degrees, which has been checked against the boiling point of water. Correction for barometric pressure and exposed thread has not been found necessary owing to the relatively small amount distilling in the intermediate stages. The diameter of the thermometer, however, should be less than half the diameter of the still head. The thermometer is so placed that the top of the bulb is level with the side neck of the distilling flask, and the top of the bead column must be at least $\frac{1}{2}$ in. from the bottom of the bulb. Three 120-c.c. glass-stoppered Erlenmeyer flasks, numbers I, II and III, are used for catching the distillates. Weigh the flasks empty and weigh the sample in flask II.

Transfer the weighed sample to the distilling flask; distill into flask II with a carefully regulated and protected flame, not faster than one drop per second. At the temperature of 130 deg. C. stop the distillation and allow the condenser to drain well. Replace flask II with flask III, resume the distillation, stopping when the temperature of 200 deg. C. is reached; then weigh the fraction in flask II (designate as fraction "A"), and the fraction in flask III (designate as fraction "B").

Place fraction "A," contained in flask II, in a similar distilling flask and distil to 95 deg. C., catching the distillate in flask I, allow the condenser to drain, replace flask I with flask II, and distil to 120 deg. C. Occasionally the flask will go dry before 120 deg. C. is reached. In such event allow the flask to cool, so that vaporization will not take place when the stopper is removed, and add a small portion of fraction "B" (3 c.c. has been found sufficient in all cases to drive over all the lighter oils), and then resume the distillation. All of this process of distillation must be performed slowly, especially when running off the portion between 95 deg. and 120 deg. C.; about 1 drop every 2 seconds is the correct rate.

Now weigh the fraction in flask I (designated as fraction "C") and the fraction in flask II (designated as fraction "D"). Put fraction "C" into a similar distilling flask and re-distil to 95 deg. C., catching the distillate in the same flask, No. I. If difficulty is found in reaching this temperature, owing to the flask going dry, let the flask cool and add a small portion (3 c.c. is sufficient) of fraction "D." This final distillation must be made very slowly, starting with one drop in two seconds and finishing with one drop in four seconds. Finally weigh flask I. Designate its contents as fraction "E."

The weighing flasks are not cleaned between distilla-

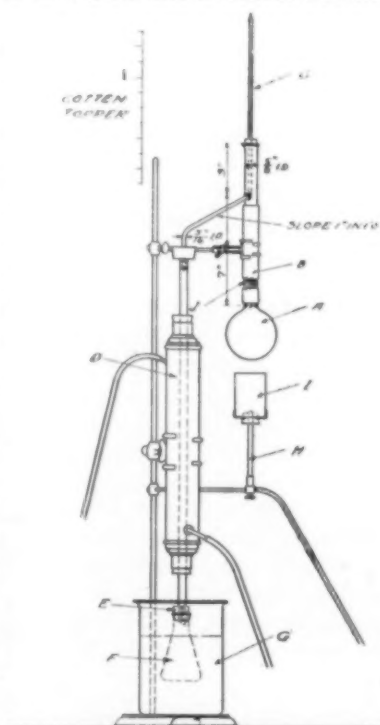


FIG. 4. LIGHT-OIL STILL FOR FRACTIONATING

- A—200 c.c. Distilling Flask.
- B—Asbestos Wrapping.
- C—200 c.c. Ther. Grad. 1°.
- D—Condenser—15-in.
- E—Slit in Cork Filled with Cotton.
- F—120 c.c. Erlenmeyer GG. Stopper.
- G—Ice Water.
- H—Bunsen Burner.
- I—Flame Protector.
- J—5 1/2-in. G. M. M. Glass Beads.

tions. The distilling flasks and condenser must, however, be clean and dry for each new fractionation.

METHOD OF CALCULATION

Call last fraction to 95 deg. "E"
Call first fraction to 95 deg. "C"
Call fraction 95 to 120 deg. "D"
Call fraction to 130 deg. "A"
Call fraction 130 to 200 deg. "B"

"E" is equivalent to the weight of the true benzene content.

"D" + ("C" - "E") is equivalent to the weight of the true toluene content.

"B" + ("A" - "C" - "D") is equivalent to the weight of the true solvent naphtha content.

In order to figure percentages by volume, take the specific gravity at 15 deg. C. of fraction "E" for the benzene, of fraction "D" for the toluene, and of fraction "B" for the solvent naphtha, and make the necessary calculations to percentages by volume of the original light oil. On account of the small size of the distillates, the determination of specific gravity will usually have to be made in each case with a carefully calibrated pycnometer. If possible use a 10 c.c. pycnometer, fitted with a thermometer.¹ These materials have large coefficients of expansion, which necessitates careful and rapid weighing.

CORRECTION FOR PARAFFIN HYDROCARBONS

In some cases such substances may be present, and are indicated by the low specific gravity of the fractions. The method for calculating the percentage of non-aromatic hydrocarbons is based on Dr. Rittman's suggestion.² The following figures are based for the specific gravities³ in question.

Specific Gravity at 15 Deg. C. on	Aromatics	Non-aromatics
Fraction "E"	.885	.720
Fraction "D"	.872	.730
Fraction "B"	.869	.760

The specific gravity of the fractions have been determined,

Let X = per cent aromatics of any fraction of original light oil.

Let Y = per cent non-aromatic of any fraction of original light oil.

Let G = sp. gr. determined.

Let A = sp. gr. aromatic fraction when pure.

Let N = sp. gr. non-aromatic constituents.

Let P = per cent of original light oil of fraction under consideration.

$$X = \left(\frac{G - N}{A - N} \right) X P$$

$$Y = \left(\frac{A - G}{A - N} \right) X P$$

It is evident that the foregoing method of estimation of benzene, toluene, and solvent naphtha is a purely arbitrary one, and it may be open to some criticism on this account, but a considerable amount of experience with it has shown it to give satisfactory results, both by com-

parison with other methods and by tests on artificial mixtures, containing known quantities of the materials in question.

Table I shows the results of estimations on samples made up with known quantities of benzene, toluene and solvent naphtha.

Test	Sample Taken, c.c.	Actual Composition of Mixtures			Estimated by Method—Sol. Nap. and Loss (by Diff.)		
		Benz., %	Tol., %	Solvent Naphtha, %	Benz., %	Tol., %	%
1	99.40	50.0	25.0	25.0	49.85	25.12	25.03
2	88.06	67.5	17.5	15.0	66.58	17.63	15.79
3	57.42	70.0	20.0	10.0	69.37	19.55	11.08
4	98.98	75.0	15.0	10.0	74.43	14.71	10.86
5	96.86	80.0	10.0	10.0	80.04	9.25	10.71
6	63.25	40.0	40.0	15.0	41.0	43.09	10.31

Test 6 is illustrative of several experiments that we have made which show that the method is not applicable to mixtures containing less than 50 per cent. of benzene. In cases of such mixtures, if a higher degree of accuracy is necessary, the fractions obtained from the preliminary distillation are mixed together and enough pure benzene is added to bring the composition of the sample within the proper limits.

In Table II we show the results of distilling samples at a too rapid rate. In test 1 the last fractionation was run at the rate of one drop per second, causing the separation of benzene to be inefficient. Test 2 was run rapidly throughout all the distillations.

Test	Sample Taken, c.c.	Actual Composition of Mixtures			Estimated by Method—Sol. Nap. and Loss (by Diff.)		
		Benz., %	Tol., %	Solvent Naphtha, %	Benz., %	Tol., %	%
1	99.40	65.0	20.0	15.0	65.40	18.92	15.68
2	95.83	70.0	15.0	15.0	73.92	13.13	12.95

Table III shows results of estimations made by this method compared with analyses of light-oil samples made according to the method of Wilson and Roberts.⁴

Estimated by Method Given			Test	Estimated by Method of Wilson and Roberts		
% Benzol	% Toluol	% Solvent		% Benzol	% Toluol	% Solvent
48.0	20.2	11.0	1	48.9	19.8	12.7
40.0	15.6	...	2	41.4	15.5	6.2
59.1	16.1	11.2	3	60.0	15.3	9.0
44.1	15.9	8.5	4	45.8	15.2	6.2
33.0	30.2	11.7	5	36.0	28.0	11.4

Test 5 shows results obtained from an oil containing too high a percentage of toluene for efficient fractionation by the method given. The benzene content should have been increased by the addition of a known quantity of C. P. benzene, but this was not done on this test.

APPROXIMATE ESTIMATION FROM THE BOILING-POINT TEST

It is interesting to note that a quick approximate estimation of the relative proportions of benzene, toluene and solvent naphtha in light oils of ordinary composition may be made directly from the results of the usual "boiling-point tests." The results are of considerable value to the practical benzol-plant operator. The method of making this test will be described in a succeeding issue.

The benzene is taken as the average of the amounts distilling at 95 deg. and 100 deg. C.

The toluene is taken as the amount distilled between 100 deg. and 120 deg. C.

Solvent naphtha is taken as 2/3 of the amount dis-

¹ Or use the Drushel pycnometer (U. S. Bureau of Mines, Bulletin 125, p. 27).

² Met. & Chem. Eng., 1915, Vol. XIII, p. 632.

³ Some light oils contain carbon disulphide, the high specific gravity of which may completely mask the presence of any paraffins in the benzol fraction. In such cases the amount of carbon disulphide must be determined (V. Lunge, C. 31 Tar and Ammonia, 5th ed., p. 982) and a suitable correction applied.

⁴ Journ. Gas Lighting, May 2, 1916.

tilling between 120 deg. and 180 deg. C. on unwashed materials, and as the amount distilled between 120° and 180° C. on washed materials.

In the case of light oils containing much over 60 per cent benzene, the per cent of toluene as estimated by this method will be considerably too low. When samples contain much over 20 per cent toluene the per cent toluene as estimated by the method will be considered too high (See Table V.) We have found it to hold fairly good when light oils contain from 45 per cent to 60 per cent benzene, and from 10 per cent to 20 per cent toluene.

Thus suppose we have a light-oil sample which gives the following results by the "boiling-point test:"

Temperature	% Total Light Oil Distilling
95 deg.	54
100 deg.	60
120 deg.	78
180 deg.	90

Then the per cent of benzene is the average of 54 and 60 = 57 per cent.

The percentage of toluene is 78 — 60 = 18 per cent.

The percentage of solvent naphtha is 90 — 78 = 12 per cent.

TABLE IV

Results of tests of known mixtures containing correct proportions of benzol, toluene and solvent, for estimation by boiling-point method.

Made Up from Pure Materials				% Petroleum Wash Oil	Estimated by "boiling points"		
No.	% Ben.	% Tol.	% Sol.		% Ben.	% Tol.	% Sol.
1	60	10	10	20	57	9	8
2	55	20	15	10	52	17	14
3	50	20	15	15	46.5	17	13
4	45	15	15	25	44.5	14	14

TABLE V.

Results of tests of known mixtures containing incorrect proportions of benzene, toluene and solvent for estimation by "boiling-point" method:

Made Up from Pure Materials				% Petroleum Wash Oil	Estimated by "boiling points"		
No.	% Ben.	% Tol.	% Sol.		% Ben.	% Tol.	% Sol.
1	70	15	10	5	71	9	8
2	30	50	20	..	9	66	17
3	20	60	20	..	0.5	83.5	16

TABLE VI

Comparison with fractionations, actual coke-oven light oils used.

No.	Fractionated by Method of Wilson and Roberts			Estimated by "boiling points"		
	% Benzene	% Toluene	% Solvent	% Benzene	% Toluene	% Solvent
1	47.5	15.7	8.9	48	14	9
2	47.0	14.0	6.0	46	14	9
3	46.3	13.8	6.0	48	13	9
4	44.8	15.3	7.6	45.5	14	9
5	41.4	15.5	..	40.5	14	10

It will be seen from Table IV that the percentage of light-oil constituents as estimated by the "boiling-point" test runs somewhat lower than the true values. However, on an unwashed coke-oven light oil this test will give values that check the real composition somewhat more closely (cf. Table VI). But even then about 1 per cent should be added to the toluol as determined.

Other methods for the analysis of light oil will be briefly abstracted for the sake of convenience. We have used all of these methods and found them to give good results when proper care is exercised in carrying out the distillations, but they all have their limitations in that they require comparatively large samples.

Hugh W. James, A. R. C. Sc. (*Jour. Soc. Chem. Ind.*, Vol. 35 p. 236, and *Jour. Gas Lighting*, Vol. 133 p. 531).

The Determination of Toluene with a Note on the Application of the Method to Benzene and Xylene.

James distils 250 cc. of the oil to 140 deg. C. and through a six-bulb LeBal-Henninger column (other efficient columns may be used). The distillate is then distilled catching six fractions viz: to 90 deg. C., 90 to 100 deg. C., 100 to 109 deg. C., 109 to 112 deg. C., 112 to 120 deg. C., and residue at 120 deg. C. All of these fractions except the first and last are redistilled using a column as before. All that distils below 110.6 deg. is placed with the first fraction, and all above that with the last. This gives essentially a mixture of benzene and toluene in the first case, and of toluene and xylenes in the second. A boiling-point determination of each of the two fractions is then made and the percentage of toluene estimated from tables given. Figures are given showing the percentage of toluene in artificial mixtures as compared with the percentage estimated by method. On the whole very good results were obtained, but this method would not be so applicable to quantities as small as, say 50 cc.

Dyke Wilson and Ivan Roberts (*Gas Record*, March, 1916, and *Jour. Gas Lighting*, May 2, 1916). Determining Benzene, Toluene and Solvent Naphtha in Light Oils.

Approximately two liters of oil are used in this method. The oil is first purified by washing with sulphuric acid, then soda, and the product distilled with steam. This purified oil is placed in the still. The still is provided with a 40-in. Hempel column filled with glass balls for thirty-six inches. Attached to the top of the Hempel column is an efficiency vertical reflux condenser. By adjusting the temperature of the bath of the reflux, any degree of dephlegmation desired may be attained. Benzene is taken as the amount distilling to 81 deg. C. plus benzene in the intermediates. Toluene is taken as the amount distilling between 109 deg. and 111.5 deg. C. plus toluene in the intermediates. Percentages in the intermediates are estimated from boiling determinations in a side-neck flask, and comparison with tables. Solvent naphtha is taken as the difference between the amount of washed oil charged and the benzene and toluene as determined, less any distillation losses. Temperatures are measured by an accurate thermometer graduated in fifths of degrees inserted vertically in the top of the column above the reflux. The advantages of this method are that it gives large volumes of pure materials, only about 4 per cent of the total washed oil being in the form of intermediates.

Gustav Egloff (*MET. AND CHEM. ENG.*, Vol. 16, No. 5, p. 259). The Analysis of Light Oils.

Egloff uses a large sample (approximately two liters). This is placed in a copper still of about four liters capacity. The column is about eight feet in length, made up of six sections of 3/4-in. iron pipe one foot each in length with a top section eighteen inches in length. Sections are connected by means of sleeves. Between adjacent sections there is a 30-mesh iron gauze used as a diaphragm to support an 8-inch column of 2-in. glass rods of 1/2-in. diameter. Above each section of glass rods a 1/4-in. iron pipe is screwed into the column which in turn is screwed into a 1/4-in. main running down the outside of the column. This main at the lower end passes into the still, the lower end being just above the bottom, forming a seal when the light oil is charged. This small pipe then acts as a reflux for each of the sections. A thermometer is placed in the top of the column.

Distillation is conducted at a rate of two drops per second. The amount distilling to 95 deg. C. is taken as benzene, the amount from 95 deg. to 125 deg. C. as toluene, and the amount from 125 to 165 deg. C. as the solvent naphtha present in the starting mixtures. Various tables are given with a drawing of the still. The tables show the efficiency of the fractionation made and the accuracy which can be expected.

Egloff purifies the oil before fractionation by washing with sulphuric acid and soda, and then steaming with live steam to 180 deg. C. This oil distillate is dried and placed in the still for fractionation. Paraffins are estimated from the gravity of the fractions obtained.

Rittman (*Met. and Chem. Eng.*, 1915, p. 682) has described a method for the determination of benzol in light oil mixtures by nitration.

Method for the Determination of Wash-Oil in Light Oil

Take a one liter sample of light oil (noting the temperature at which it is measured) and place in steam still of about one gallon capacity. After making sure that all joints and connections are tight, dry-distill to 120 deg. C. Then introduce steam, keeping the temperature between 120 deg. and 130 deg. Distil until 400 cc. of water have passed over. The apparatus is arranged as shown in Fig. 2, except that a one-liter separatory funnel is used. It is well to place an asbestos guard or shield between the separatory funnel and the flame, reducing the danger of fire. After distillation, the light-oil distillate is brought to the same temperature as the sample as first measured, and its volume is determined by means of a graduate. The volume of the oil left in the still is also measured. This volume added to that of the distillate should equal 1000 cc. if the still is carefully drained. The discrepancy should not exceed 5 cc. This residual oil is now cooled to 15 deg. C. and naphthalene filtered off by suction, drying as well as possible, and the loss in volume of the oil noted.

A fresh sample of wash-oil of the same type used in scrubbing the gas for light oil is taken for a blank.

Take 1000 cc. of this for a sample. Distil at 120-130 deg. C. in the same apparatus until 400 cc. water has passed over (as in the light oil distillation). Measure the volume of distillate, and calculate the amount of residue by difference.

CALCULATIONS

Let A = per cent oil residue (corrected for naphthalene) from first distillation.

Let B = per cent oil residue from blank (second) distillation.

Then: Per cent wash oil in sample = $\frac{A \times 100}{B}$

The Society for Electrical Development has recently issued two very interesting and instructive booklets on "Industrial Heating as a Central Station Load." Part One deals with electric furnaces as used in steel making and takes up the classification, operation and regulation of the principal furnaces. Other applications are also discussed. Part Two deals with welding apparatus, japanning ovens and similar work. Dwight D. Miller, whose paper on Non-Ferrous Metal Melting will be found elsewhere in this issue, is at the head of the engineering department. The Society's headquarters are in the United Engineering Societies Building, 29 West Thirty-ninth Street, New York.

Synopsis of Recent Metallurgical and Chemical Literature

Flotation

Cascade Flotation.—In the August, 1917, issue of the *Mining Magazine*, a description is given of the cascade flotation system developed by Messrs. Seale and Shellshear at the Junction North Mine, Broken Hill. It is claimed that the power required by the process is very small. The principle adopted by Messrs. Seale and Shellshear is that of the cascade; that is to say, the stream of pulp is caused to fall into water, the incoming stream entrapping air, which is subsequently released, and on rising acts as the buoying agent. This method of catching and compressing air by falling water is sufficiently well known, for it has been applied for the purpose of supplying compressed air to mines, a characteristic case being that introduced several years ago at Cobalt, Ontario. The cascade system has been applied recently for flotation purposes in America, particularly in the Crowfoot and Wilfley methods. Minerals Separation, the Sulphide Corporation and the Zinc Corporation have severally improved the Seale and Shellshear process. It is understood that Minerals Separation, the controller of the patents, has sent a representative to America to explain the process and experiment on its application to copper ore. No information is at hand relating to the construction of the plant actually employed. British Patent 10,666 of 1915, granted to Messrs Seale and Shellshear, describes the process. According to this patent the pulp is fed to a mixing box B, open at the top, from which it passes downward to a separating box A, also open at the top, through a pipe B', which delivers the pulp below the surface of the water in A. The baffle A' is

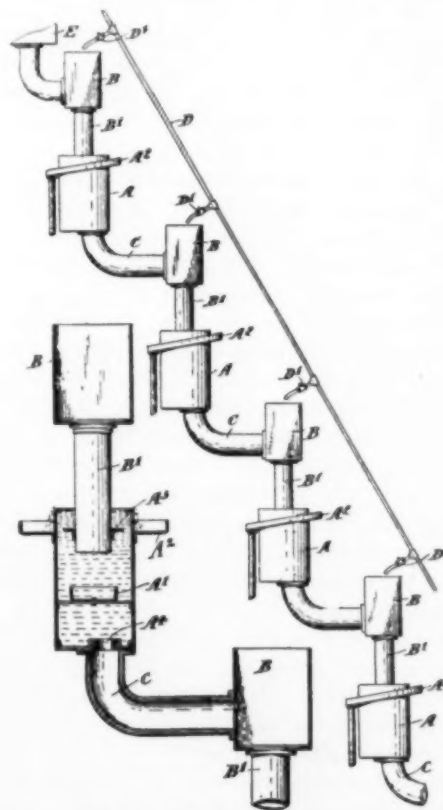


FIG. 1—DIAGRAM OF THE SEALE-SHELLSHEAR CASCADE FLOTATION PROCESS

placed in the box A so that the downward current of pulp and air shall be broken. The liberated air carries some of the sulphides upward, and after passing the baffle A² they are discharged into the annular launder A³. The unaffected pulp passes through the orifice A⁴ and the pipe C to the next mixing box B. The flow of the pulp through the pipe C causes a vigorous agitation. Additional water is introduced at the head of each successive mixing tank to compensate for that removed with the concentrate. The process has proved extremely successful at the Junction North, Central, and South Blocks mines. The details of construction of the actual plants are of course only suggested by the drawings in the patent specification. In practice the process is applied to the preferential separation of galena and blende. At the Central mine, half of the agitation plant has been laid by, in favor of the new process. According to the new method at the Central, the mine ore is first jigged for the removal of as much galena as possible, and the tailing, after regrinding, is sent direct, without any tabling, to the Seale-Shellshear plant. The oiling medium is added before the pulp goes to the flotation apparatus. The lead is removed in the first few separation boxes. Subsequently acid is added, and the blende is thereby floated.

Recent Developments in Germany

Chemical Developments.—*The Chemical Trade Journal and Chemical Engineer*, Sept. 22, 1917, publishes a review of recent chemical developments in Germany, taken from the *Neue Zürcher Zeitung*. Systematic investigations into the properties of coal have been carried on by the "Kaiser Wilhelm Institute für Kohlenforschung," and have yielded important industrial results. The treatment of coal with liquid sulphurous acid at ordinary temperatures has produced viscous, golden-yellow mineral oils, the amount produced being 5 kg. per metric ton. A process has also been elaborated by which through heating naphthalene under pressure in the presence of aluminium chloride, an oil is produced which can be used for illuminating purposes in the same manner as petroleum. Finally, by treating with ozone, it has been found possible to alter the carbon compounds in coal to compounds soluble in water, the chemical importance of which cannot at present be estimated.

The utilization of lignite has been greatly extended. In the first place it is being used extensively as a fuel in the industrial establishments which have recently sprung up in the Central German lignite fields, especially in the neighborhood of Bitterfeld and Halle a/S, where the German air-nitrate factories are situated. A process has been discovered by which twice the usual amount of ozokerite can be obtained from lignite, and the gas is being more extensively used for heating and smelting purposes.

In the field of the exploitation of nitrates directly from air a new process has been discovered, which works with quadruple air velocity through the reaction space and produces a result about 80 per cent higher than could be obtained before.

In the metal industry further progress has been made with the production of substitutes for copper, brass and bronze, especial mention being made of the different zinc and lead alloys, and of the increasing importance of aluminium.

Recently there have been new developments in ore smelting. With copper schists the metallurgical possibility of going as low as 0.7 per cent has been shown, whereas formerly the average lower limit was 2.5 per cent. Operations have been commenced upon large deposits of sandstone containing white lead. Successful experiments have been made in obtaining aluminium from clay, which will, it is claimed, make Germany independent of foreign bauxite in future. With nickel ores the workable limit has been reduced from 2.5 to 1.5 per cent. A process has also been discovered for obtaining nickel and cobalt from pit waters containing these substances.

In the German rubber industry the situation is said to have been eased by the progress made in rubber regeneration. The idea of exploiting German caoutchouc plants has been given up.

Tendency Toward Combines.—*The Neue Zürcher Zeitung*, according to the *Chemical Trade Journal and Chemical Engineer*, follows up its review of the progress made in industrial discoveries and processes in Germany during the war with a review of the progress accomplished in the field of economic organization in that country in the same period. The chief characteristic of the third year of war has, it is said, been the tendency toward compulsory and voluntary syndication of industrial concerns. Compulsory syndication has been demanded by the Government to secure economy in view of the scarcity of material and the shortage of labor; while voluntary syndication has been suggested and carried out by the parties interested by way of preparation for the prospective economic war, and in order to facilitate the return of peace conditions in the economic sphere, though in some cases this action has been in response to suggestions and hints on the part of the Government.

The great union in the chemical industry has been voluntary. This combine, which is for a period of fifty years, is primarily of a defensive nature. The constituent works retain complete independence and freedom of action, but profits will be pooled, all manufacturing experiences exchanged, and all products produced in at least two places. This arrangement, it is hoped, will do much to further the exploitation of new discoveries and to promote technical progress, with the result that the position of the German chemical industry in the world market will be strengthened.

Agreements with the same object have recently been made between the dyeing and explosives groups of industries. Details of the compact have not yet been made public. It is only known that an agreement has been made concerning the peace-time production and the sale of such articles as have always been produced by both groups. The explosives group consists of a combination of the Dynamite Trust and the powder group, which before the war were accustomed to divide profits according to a definite scale.

Since the outbreak of the war the largest German explosives factory, the Dynamit A. G. Nobel, in Hamburg, has been the center of German dynamite interests. An examination of the list of firms combining to form the German explosives trust and the powder trust, with those forming the aniline combine, shows that the German chemical industry is closely united.

In addition to the combines properly so-called, there have been numerous amalgamations and fusions of indi-

vidual concerns, which are further evidence of the general tendency toward the development of large organizations in German economic life. Numerous individual men of business are retiring into private life, their places being taken, as a rule, by large companies and combines. This concentration has been further promoted by measures taken or proposed within the States, such as the proposal to tax turnover. Were such a proposal carried into effect, it would probably give a great advantage to the large enterprises which carry on the whole range of production from the raw material to the finished product, so that the turnover is not subject to frequent charges. Such measures have brought about a similar concentration in trade, as they have resulted in many liquidations of smaller firms.

The rôle played by the banks in these fusions, amalgamations, and absorptions is much less important than in peace times; firstly, because the undertakings in question have as a rule made such large war profits that they can dispense with the assistance of banks; and, secondly, because the banks themselves are undergoing a process of concentration, which is, however, being carried on below the surface. The chief reason for this tendency toward concentration is that the problems confronting German finance on the conclusion of peace (the problems connected with supplies of raw materials, resumption of issue, reconstruction of credit organization, etc.) can be accomplished only by institutions of extraordinary capacity and internal strength. The result of this must perforce be a further reduction in the number of medium-sized houses.

Recent Metallurgical and Chemical Patents

Potash

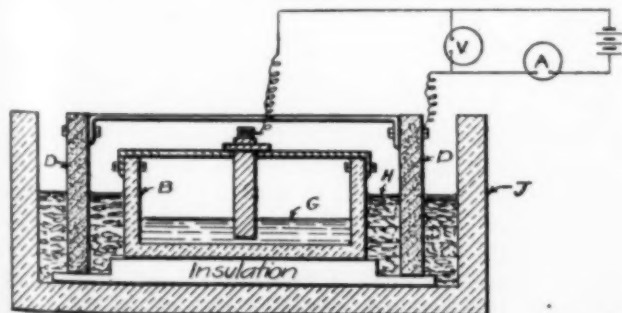
Potash from Kelp.—A method for the production of potash from kelp by the use of electrical endosmose is patented by HARLAN L. TRUMBULL of Seattle, Wash.

The moist kelp, which may or may not be freshly harvested (preferably after first being ground or cut into pieces of conveniently small size), is pressed into the anode compartment of a suitable, divided-electrolytic cell wherein it makes intimate contact with and moistens a porous partition.

The container J (Fig. 1) may consist of any material not already attacked by chlorin.

The anode D may consist of any electrode material which is relatively inert chemically in the presence of free chlorin, such as amorphous carbon, graphite or cast magnetite.

The cathode G is of mercury and during electrolysis makes intimate contact with the above-mentioned porous partition on the opposite side from the kelp indi-



CROSS-SECTION OF KELP-TREATING APPARATUS

cated by H. By electrolysis, mercury is converted into an amalgam of alkali metals, which amalgam is decomposed in the presence of water to furnish a solution of alkalis. This decomposition may be hastened by the use of contact agents such as graphite, carbon, nickel or certain other solids. The decomposition of the amalgam may be effected either during the electrolysis or after its completion. In either case the resulting solution is a mixture of alkalis containing a high percentage of caustic potash. The alkalis may be obtained in solid form by evaporating the solution to remove water and other volatile substances which are present.—(1,238,600, Aug. 28, 1917.)

Potash from Refuse Slate Dumps.—FRANK G. BREYER of Palmerton, Pa., has patented a method for recovering potash from carbonaceous material and refuse, such as shales, slates, peats, waste coal, culm, etc. He proposes to burn the material in a blast or other type of furnace with suitable additions of limestone to form a slag with the ash in the charge. The potash is volatilized and is caught in dry dust catchers or wet gas scrubbers, or in a Cottrell apparatus.—(1,236,903, Aug. 14, 1917.)

Potash from Feldspar.—WALTER GLAESER of Brooklyn, N. Y., patents a process of producing potash from feldspar. The process consists in burning the material at a low red heat, then suddenly cooling the heated material, mixing burnt lime with the material in the proportions of less than 20 per cent, fusing the mixture at 1600 deg. C. and then subjecting the ground product to the action of sulphuric acid to form potash alum. The material may be used for fertilizer before making potash alum if desired, and is stated to give good results.—(1,237,197, Aug. 14, 1917.)

Petroleum Technology

Preventing Sedimentation.—ARTHUR L. BROWN of Wilkesburg, Pa., patents a method of treatment of hydrocarbon oils for the prevention of sedimentation. The patent is assigned to the Westinghouse Electric & Mfg. Co.

When hydrocarbon oils are exposed to the air they slowly develop a dark sediment or sludge which appears to result from a slight oxidation of the oil. When such oils are used for cooling purposes, as in the tanks of electric transformers, the sediment may accumulate upon the walls of the container and cooling coils to such an extent as to greatly interfere with the dissipation of heat. According to this patent the formation of sediment in hydrocarbon oils may be prevented by the presence of small amounts of phosphorus. The amorphous or red phosphorus is used, and only a small fraction of 1 per cent of the weight of the oil is necessary to accomplish the desired result. The phosphorus may be mixed with the oil, or it may be made into a paste with glue or other suitable binder and painted upon the inner walls of the containers that are to receive the oil.—(1,234,862, July 31, 1917.)

Treatment of Oils in Presence of Aluminium.—A. M. MCAFEE of Bayonne, N. J., patents a process of oil treatment for gasoline production, using aluminium as a catalyzer, and introducing a current of chlorine gas into the oils. The operation is carried out in the regular still. The low boiling products and the hydrochloric acid produced being removed continuously during the progress of the reaction, and the volume of the

oil being kept constant by fresh additions. It is claimed that by this process gas oil is converted into gasoline with about an 85 per cent conversion. About 10 per cent of the oil is converted into gas, which may be used for heating purposes and the residue forms granules of coky carbon.

It may be that some of the catalytic action is due to the direct production of aluminium chloride in the body of oil, or it may be that the action of the aluminium on the oil in this operation is direct. It is stated, however, that the aluminium appears to exercise more catalytic activity in this process than would result from the use of a corresponding amount of aluminium chloride.

Zinc or iron may be used in lieu of aluminium, but are less advantageous. When used they are employed in the same manner as aluminium.—(1,235,523, July 31, 1917.)

A New Optical Pyrometer

An optical pyrometer for works use has been developed by the Leeds & Northrup Co., Philadelphia, Pa.

In the focal plane of a small telescope is placed the filament of a small tungsten lamp, the current for which is supplied by a storage battery carried in a case slung from the shoulder. By means of a rheostat, the observer adjusts the current through the lamp until the filament merges or disappears in the background formed by the object looked at, and thereupon reads the current from a milliammeter mounted upon the battery case. A calibration chart converts the milliammeter reading temperature.

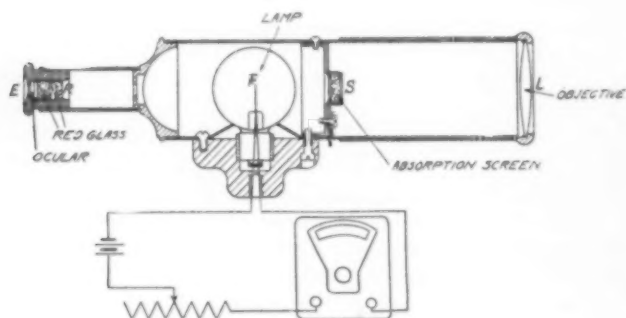


FIG. 1—OPTICAL SYSTEM AND ELECTRICAL CIRCUIT OF OPTICAL PYROMETER

It is stated that the setting can be made with great precision, due to the rapid change in the intensity of light emitted by the hot objects with change in temperature and to the sensitiveness of the eye in differentiating the brightness of superposed objects. A color screen is interposed between the eye and the focal plane so that only monochromatic light reaches the eye. Color blindness, therefore, is no hindrance to the use of the instrument, and it is claimed that different observers agree within 3 deg. C. The observer can stand 5,100 or 200 feet from an ingot, billet or furnace and get the temperature. The range is from about 1100 deg. Fahr. to the highest known temperature.

For temperatures above 2500 deg. Fahr. a dark screen is used to reduce the intensity of the light received from the hot object.

A Tin Pyrometer

An expansion pyrometer using tin as the expansion element has been developed and placed on the market by the Pyroelectric Instrument Co., of Trenton, N. J. Advantage has been taken of the fact that the thermal expansion curve of tin is practically a straight line. In this new pyrometer, tin is contained in a graphite bulb much as you would contain mercury in a glass tube in a mercury thermometer. The tube up which the melting tin rises is an open system, of graphite. Readings are made by lowering the plunger with a metal of a high melting point at the lower end, this metal making electrical contact with the rising tin, closing a circuit. Readings are then made in one of two ways. If you would want to know when 1500 deg. C. is attained, you would set the pointer on the scale at 1500 deg. C. When

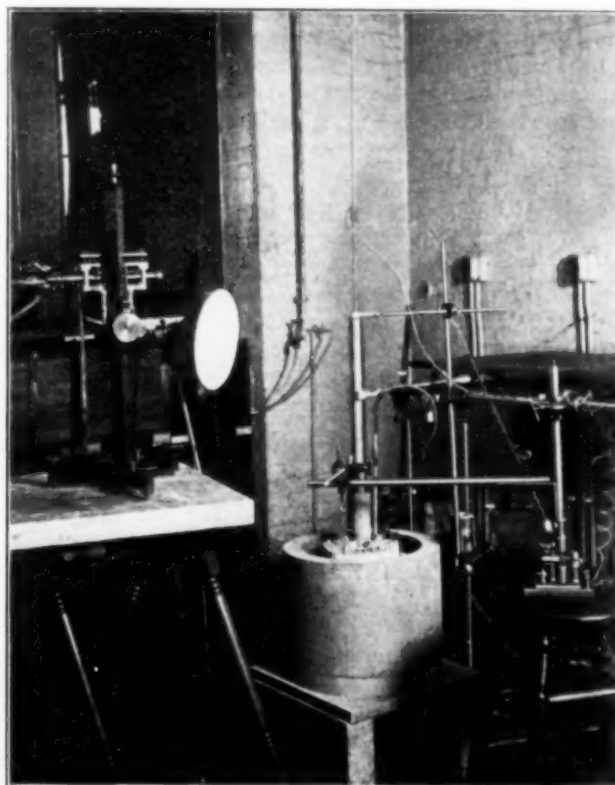


FIG. 1—CALIBRATION OF TIN PYROMETER IN NORTHROP-AJAX FURNACE

this temperature is reached, a buzzer, or any form of electrical alarm, is set into operation. To find the temperature at any time, the pointer is lowered on the scale until the alarm rings. The position of the pointer then indicates the true temperature of the tin at the time.

It is pointed out by the manufacturers that this form of pyrometer opens up possibilities for reading temperatures some 300 deg. above thermocouple limits, with a direct insertion pyrometer. It is especially adapted for integrating a mass temperature, rather than for finding a point temperature, as with a thermocouple. The expansion of the graphite is almost negligible in comparison with that of the tin. The tin does not appreciably evaporate until a temperature of presumably 2000 deg. c. is reached so that no difficulty in change of calibration is encountered.

Personal

Mr. Lawrence Addicks, consulting metallurgical engineer of New York City, has gone to Burma to make a metallurgical investigation of the ores of the Bawdwin Mines. He expected to sail from Vancouver on Oct. 25.

Mr. H. F. Bardwell, who is well known to the buyers of tool steel in the East, has been appointed New York district manager for the Vanadium-Alloys Steel Co. of Pittsburgh and Latrobe, Pa., with offices at 30 Church Street, New York, N. Y.

Mr. Max H. Boehme, manager of the Seattle office of Marden, Orth & Hastings Corp., recently spent a few days at New York headquarters.

Mr. Charles C. Cheyney, manager of the Chicago office and store of the Buffalo Forge Company, has a commission in the Naval Aeronautic Corps and is Beach Engineer at Pensacola, Fla., in charge of aeroplane engines.

The appointment of Burwell S. Cutler of Buffalo as chief of the Bureau of Foreign and Domestic Commerce, Department of Commerce, was confirmed by the Senate recently. Mr. Cutler, who is well known in manufacturing circles in western New York, came into the Bureau six months ago at a nominal salary to assist in putting the organization on a thoroughly business basis. He was made first assistant chief, but since the resignation of Dr. E. E. Pratt, has been acting chief. Mr. Cutler was born in Buffalo and finished his scholastic education at Lake Forest University and Harvard. For fifteen years he has been president of an important Buffalo manufacturing concern and has been identified in an official capacity with numerous business houses and civic organizations throughout New York State.

Dr. Frederic Dannerth, head of the Rubber Trade Laboratory in Newark, N. J., addressed the Philadelphia Section, American Chemical Society, on Oct. 18, at the Houston Club, on "The Financial Prospects of Synthetic Rubber." At the same meeting Mr. G. A. O'Reilly of the Foreign Trade Department, Irving National Bank, N. Y., spoke on "The Industrial Chemist as Seen by the Banker."

Dr. Milton W. Franklin, who has been engineer of the Ozonator Department of the General Electric Co., has gone to E. F. Houghton & Co. of Philadelphia as consulting engineer. Dr. Franklin becomes a member of the Board of Directors, chairman of the Sales Committee, and assumes charge of plants and equipment and manufacturing processes.

Mr. C. F. Goodrich, assistant manager of the Buffalo Forge Company's Boston office, has left for active duty as First Lieutenant in the Ordnance Department, and is stationed at the Watervliet Arsenal.

At the annual meeting of stockholders of the Semet-Solvay Company, Syracuse, N. Y., Alfred W. Hudson, president of the First National Bank, was elected a member of the Board of Directors to succeed Frederick R. Hazard, deceased.

Dr. James J. Johnson, 549 Summer Avenue, Newark, N. J., formerly connected with the Maas & Waldstein Company in the capacity of chief chemist, has been commissioned a Captain in the Ordnance Department, to serve in the gun division. Dr. Johnson is an ex-

pert on high explosives, having been formerly associated with the duPont plants and also at the Pica-tinny Arsenal.

Mr. E. K. Judd of the Mining Department of Columbia University has been appointed managing editor of the *Bulletin* of the American Institute of Mining Engineers, vice B. A. Robinson, who resigned in June. Prof. G. A. Roush, who has been acting temporarily as managing editor since Mr. Robinson resigned, will resume his usual duties in Lehigh University.

Mr. P. J. Kroll has resigned as Pittsburgh and Middle West representative of the International Oxygen Co. of New York.

Mr. H. E. Linden of the Beckman & Linden Engineering Corporation of San Francisco, is making an extended trip throughout the East in the interest of his own company and also in the interest of the Pacific Electro-Metals Company of which the Beckman & Linden Engineering Corporation are engineers and managers.

Dr. Ralph H. McKee has been appointed to take charge of the graduate work in industrial organic chemistry (Department of Chemical Engineering) at Columbia University, New York City. Dr. McKee was at the head of the Department of Chemistry of the University of Maine from 1909 to 1916, leaving this position a year ago to enter commercial chemical work in New York City as head of the research department of the Tennessee Copper Company. While at Maine he initiated and developed the department for the making of pulp and paper, the first of its kind to be established in any college in this country.

Mr. Don R. Marsh, production manager with the Buffalo Forge Company, has given up his work to assume similar duties at Washington in the production of ammunition. Mr. Marsh will receive a Captain's commission.

Mr. Harry W. Newton has joined the staff of Falkenburg & Laucks, chemists and metallurgists, Seattle, Wash. Mr. Newton has had a long experience in the treatment of ores of the Northwestern territory. Mr. Newton first successfully worked out the treatment of Republic ores and has also done a great deal of work on ores of British Columbia and Alaska. Mr. Newton will have charge of the ore-testing department of Falkenburg & Laucks.

Messrs. Philip A. Singer and Harris Perlstein, formerly of the Industrial Chemical Institute of Milwaukee, have associated as Singer-Perlstein Company, chemical and industrial engineers, with offices in the Railway Exchange, Milwaukee. Mr. Singer was for many years with the Corn Products Refining Company as member of the Manufacturing Committee and superintendent of various departments of that corporation's plants. He has also made contribution to the technique of the ethyl alcohol from wood waste and other chemical industries. Mr. Perlstein has been connected with Mr. Singer in a number of recent enterprises.

Dr. Reston Stevenson, assistant professor in charge of physical chemistry in the College of the City of New York, has been appointed Captain of the Sanitary Corps of the United States Army.

Imports of Raw Materials Pass the Billion-Dollar Mark

For the first time in the history of American trade the imports of raw materials passed the billion-dollar mark during the fiscal year 1917. According to statistics published by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, the exact total was \$1,109,655,040, a noteworthy increase over the \$948,825,500 in 1916 and the \$632,865,860 in 1914, the last normal year before the war.

The raw materials now imported in the greatest quantities are hides, India rubber, raw silk, wool, raw cotton, copper ore and flax-seed, and important increases are recorded for furskins, gums, mineral oils, uncut diamonds, manganese ore, nickel ore, zinc ore, and dyewoods.

IMPORTS OF CRUDE MATERIALS

	1917	1914
Hides, lbs.	700,207,497	\$216,363,609
India rubber, lbs.	333,373,711	189,328,674
Silk, raw, lbs.	33,868,885	156,085,649
Wool, unmanufactured, lbs.	372,372,218	131,137,170
Fibers, unmanufactured, tons.	408,618	67,709,738
Cotton, raw, lbs.	147,061,635	40,429,326
Copper ore, tons.	613,593	32,576,082
Flaxseed, bu.	12,393,988	25,149,609
Furskins, undressed.		21,533,375
Gums, crude.		18,644,347
Mineral oils, gals.	1,034,590,849	14,109,035
Diamonds, uncut.		11,717,175
Manganese ore, tons.	656,088	10,545,986
Nickel ore, tons.	60,132	9,970,957
Zinc ore, tons.	324,767	7,596,930
Dyewoods, tons.	131,689	4,326,376

CURRENT MARKET REPORTS

The Iron and Steel Market

Unlike the case of coal, price-fixing in the iron and steel industry is proving rather a satisfactory performance for all parties concerned, there being little friction and only occasional complaint. The complaint, such as there is, comes from buyers rather than sellers, and seems to arise chiefly from misunderstanding of the principles involved. Some buyers complain, for instance, that they cannot make purchases from mills, but are forced to buy from warehouse, and when the warehouse chances to be conducted by a steel-producing interest they question whether it is not a violation of the agreement for the warehouse price to be higher than the mill prices agreed upon. The fact is that nothing has been done with respect to regulating jobbers' selling prices, and it is quite possible that nothing will be done.

The essence of the various agreements being reached between the Government and the iron and steel producers is that they will sell to the Government and its Allies at the set prices, and that in case they sell to the general public it will be at prices not higher than those set. The producers do not agree to sell to the public; they agree that when they sell it will be only under certain limitations. Whether they sell or not depends upon the amount and character of their obligations already on books and the desire they may have to take care of regular customers.

Set prices were announced Sept. 24 of \$33 on pig iron and 2.90c., 3c. and 3.25c. on bars, shapes and plates respectively, and Oct. 11 of \$47.50 for 4 x 4 billets and larger, \$50 on slabs, \$51 on sheet bars and small billets, and 2.90c., 3.15c. and 3.25c. for grooved,

universal and sheared skelp respectively. Pending the announcing of further details foundry and basic iron is held to be at \$33 at all furnaces and Bessemer at \$36.30 or 10 per cent higher. Rods are supposed to be based on Pittsburgh, other unfinished steel, and skelp, on Pittsburgh or Youngstown, and bars, shapes and plates on Pittsburgh or Chicago. This distinctly novel departure of making Chicago a basing point equal with Pittsburgh is not universally accepted in the trade as final.

BUSINESS AT NEW PRICES

There has been a fair run of pig iron business at the new prices, probably on the whole a materially larger turnover than was passing through the market before the price agreement was reached. The market had been decidedly stagnant for nearly three months. In unfinished and finished steel, on the other hand, the market has been extremely quiet and sales have been the exception rather than the rule. Some sales have been made, but in the majority of instances they were probably sales made in connection with Government orders. Before price regulation was undertaken there were certain tentative prices the Government was prescribing upon certain descriptions of steel intended eventually for war use, and manufacturers who bought steel and sold their finished product to the Government were expected to get the benefit of these special prices, documentary evidence being required by the steel mill that the material involved was for Government use. With the "one price for all" system in force such proof is requisite only in connection with priority of delivery.

ATTITUDE OF PRODUCERS

Iron and steel producers frankly admit that the new prices are quite satisfactory to them. There is an indisposition to discuss details, but there is no question that one reason why the Government regulation is accepted in such good part is that it removes a menace from the market, that in its reaction from the fictitious prices that had come to be quoted as "the market" there would have been found no definite place for the market to stop in its decline, and much confusion might have resulted. The steel makers are not allowed to combine to regulate prices, and even the "Gary Dinners" of nearly ten years ago have been frowned upon by the courts, even though those dinners were not held for the purpose of setting or fixing prices, but merely for the purpose of stimulating enthusiasm on the part of individual sellers, to adhere to prices which the market had already established. The steel makers have learned how to adhere to recognized prices, without holding meetings and making agreements, but they cannot adhere to something that does not exist. Given a schedule of prices that is prescribed as maximum they will be indisposed to regard these prices as otherwise than minimum prices also. Thus they are given a definite basis, something hitherto lacking.

ATTITUDE OF CONSUMERS

Consumers are making no particular effort to buy for forward deliveries, and the call for material for early deliveries is decidedly less than it was even a very few weeks ago. The rate of consumption of steel, for ordinary peace purposes, is undoubtedly declining, on the whole, and perhaps at rather a rapid rate. The

fact that the Government's set prices are distinctly stated to be subject to revision Jan. 1 or later tends to dispose buyers to hold off, except as to earlier deliveries, while at the same time it gives the mills a reason for not considering forward sales, on the ground that the object of price-fixing is to put all buyers, eventually, on the same basis, and if prices are to be revised Jan. 1 sales for delivery beyond that date would at once divide buyers into two classes.

The whole trend of the situation, under the system of fixed prices, is to reduce the volume of forward commitments and bring the market more to a hand-to-mouth basis. The buying pressure does not furnish the usual index as to prospective consumptive requirements. In many directions these will necessarily be large. While building operations have been decreasing constantly, and are unlikely to be heavy at any time during the war, mines and factories are, in the main, to operate at the fullest possible gait, and their upkeep involves the use of much steel. Transportation facilities must be maintained, increased if possible, and that must involve the consumption of much steel if the object is attained.

THE RAILROADS

There is very little light on the prospective iron and steel demands of the railroads. For several months they have been buying scarcely anything, and there have been no large orders for rolling stock since the early months of the year, except the purchases by the Government and its Allies, which are hardly likely, for any length of time, to equal the ordinary buying of the domestic roads. The Interstate Commerce Commission is to open the 15 per cent rate advance cases, the first hearings being scheduled for Nov. 5, but whether this will result in the railroads being given the relief they insist they should have is a question. There is talk of the Government financing some railway purchases, particularly of rolling stock, but some of the railroads explain that they want to make money, not borrow it, and if they can only buy what they need by the Government lending them money it means eventual Government ownership. It seems far from improbable that the status of the railroads, as to buying of iron and steel, will not be established until there is Congressional legislation at the coming session, either by way of directing the Interstate Commerce Commission to arrange rate advances on the ground that the gold dollar is permanently depreciated, or accepting responsibilities, by way of railway financing, that may lead to eventual Government ownership. Meanwhile the prospective consumption of steel for commercial purposes, say over the next twelvemonth, can hardly be gaged when so important a line of consumption is surrounded with such doubts.

PRODUCTION

October, traditionally the month in the year of record outputs, has made a sorry showing, with no material increase over the rates of the summer months. While there are many difficulties in the way of full production, coke is easily the dominant factor. There is not sufficient coke to supply all the furnaces able otherwise to operate, and steel production is correspondingly curtailed. With the most conservative estimates of productive capacity, the actual production in both pig

iron and steel is not over 90 per cent of capacity, while some estimates are on the basis that steel production at least is only between 80 and 85 per cent of capacity. Thus far this year the output of pig iron has been slightly less and the output of steel slightly greater than in the corresponding period of last year, although capacity is greater through the new construction.

Non-Ferrous Metal Market

Friday, Oct. 26.—An interesting development in the resale of copper was brought about a few days ago when Eugene Meyer, Jr., in charge of the regulation of non-ferrous metals, issued a letter to a firm of metal brokers stating that metals sold above the prices fixed by the Government are liable to seizure.

The statement of Mr. Meyer clears up a much disputed point in the copper trade. Leading copper authorities who were informed of the opinion expressed by Mr. Meyer were not disposed to agree with him as to power of the Government to seize metal sold above the fixed prices in cases where the seller had purchased the metal above the fixed figures.

That Mr. Meyer's warning of seizure is not being seriously regarded is evidenced by sales of spot copper recently at 26 cents to as high as 29 cents. Some consumers are willing to pay premiums for spot metal as they face the alternative of either closing their plants or conceding the price asked by holders of spot metal.

The next thing that the metal trade is looking for is an announcement from Washington of a census on all metal holdings in the country. Although no official word has been given out on this score, it is learned that details of stocks of metals held by consumers and dealers on a certain date are essential before Government control of the metals will be running smoothly.

Copper.—As stated above, spot copper has changed hands at prices ranging from 25 cents up to probably 29 or 30 cents. However, these are resale lots and practically no copper can be purchased from producers at any price. This condition is very serious for consumers needing supplies as most of them are afraid to buy any copper at over the Government price of 23.50 cents. A new ruling by the Government is badly needed to relieve this situation.

Tin.—Arrivals in October up to the 23rd were very low, totaling only 1900 tons, with 4300 tons afloat. Following a period of dullness about a week ago, the market has become firmer and a steady demand has developed. Banca tin is scarce and 60 cents has been bid for it. Chinese No. 1 is extremely scarce. Spot Straits is quoted at 61.62½ cents.

Lead.—The Trust further reduced its price on Oct. 18, making it 6.50 cents, New York. The outside market is 6.25 cents. The market is unsettled.

OTHER METALS

Antimony, Chinese and Japanese, pound.....	0.14—0.14½
Aluminum, No. 1 Virgin, 98-99 per cent, pound.....	0.37—0.39
Magnesium, metallic, pound.....	2.00—2.60
Nickel, electrolytic, pound.....	.55
Cobalt, pound.....	2.70
Cadmium, pound.....	1.50
Quicksilver, flask.....	100.00
Silver, ounce.....	0.82½
Platinum, pure, ounce.....	105.00
Palladium, ounce.....	115.00

Spelter.—The spelter market has been very dull. Producers are not interested in selling at present prices as they are very near production costs. The normal quotation for prompt spelter is 8.25 cents, New York.

Chemical Market

COAL TAR PRODUCTS.—Coal tars with the exceptions of Phenol, Naphthalene and Toluol have generally been subject to decline, owing to the export restrictions and difficulties in securing permits partly to Japan and Spain, which countries have been heavy buyers in this market for the past few months.

Benzol.—Values in this market are considered rather low, with quantities having accumulated, owing to the fact that the export movement is more or less suspended.

Aniline Oil.—Stocks are rather large in some quarters, and as this product is one requiring a license for export it does not show much improvement.

Benzoate of Soda.—A decidedly upward turn has been noted in this market, a prediction of a number of the more important factors. Some of the smaller producers not financially sound have been forced out.

Dinitrochlorbenzol.—Demand is not very heavy and prices are not particularly strong, owing to difficulty in securing export licenses.

Toluol.—A fair movement is noted in this product and the general demand has improved somewhat, but the greater part of the production is going into the manufacture of explosives.

Monochlorbenzol.—It is indicated from various sources that stocks are quite ample, however, there does not seem to be a gratifying movement into consuming channels.

Orthonitrophenol.—A firm situation is noted with supplies scarce and efforts to locate material have been without results. — One of the producers making the para and ortho recently sustained a loss by fire, and this tended to strengthen an already firm market.

Naphthalene.—A very firm market seems to prevail and some of the leading interests are inclined to sit tight rather than sell at figures generally quoted.

Phenol.—The situation seems to be gradually growing firmer and the production has been well sold up for the first half of the coming year and considerable business has been booked during the past fortnight.

Dinitrophenol.—The product has been in better demand for the fortnight and prices quoted seem to be firmer.

HEAVY CHEMICALS.—There has been a general reduction in all products which come under this classification, principally due to difficulties encountered in securing licenses and to the export restrictions imposed by the Government.

Acids.—Enormous demand from both foreign and domestic sources have swamped the markets for nitric, muriatic and sulphuric acids, including oleum. Prices have advanced for all grades.

Caustic Soda.—Not much of a recovery is noted and the market continues rather weak owing to the embargo placed by the Government, which absolutely prohibits the exportation of this product and little business of any consequence is passing.

Soda Ash.—A very uncertain situation exists and business is somewhat weakened, spot material being very scarce and special interests do not seem quite so bold.

Bleaching Powder.—The market for this product continues to be rather neglected and prices have

dropped to a low level. Stocks are ample and buyers do not show much interest.

Cyanides.—An easier market prevails with more liberal offers of the soda and mixture. The potash continues scarce, however, and but little is available.

Bichromate of Soda.—A sharp decline is noted in this market, and prices named are at a low level.

Bichromate of Potash.—A weaker tone is noted and prices are not quite as firm as of a fortnight.

Chlorates.—There seems to be a downward movement in both potash and soda and prices are somewhat lower.

Copper Sulphate.—A very firm market is reported in this product and most of producers are not inclined to quote.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET OCT. 25, 1917

Acetic anhydride.....	lb.	1.90	—	2.00
Acetone, drums.....	lb.	.36	—	.37
Acid, acetic, 28 per cent.....	lb.	.06	—	.06½
Acetic, 56 per cent.....	lb.	.11	—	.12
Acetic, glacial, 99½ per cent, carboys.....	lb.	.38	—	.40
Boric, crystals.....	lb.	.72	—	.72½
Citric, crystals.....	lb.	.08	—	.08½
Hydrochloric, C.P.....	lb.	.02½	—	.02½
Hydrochloric, 20 deg.....	lb.	.02½	—	.02½
Hydrochloric, C.P., conc., 22 deg.....	lb.	.02½	—	.02½
Hydrofluoric, 30 per cent, in barrels.....	lb.	.06	—	.06½
Lactic, 44 per cent.....	lb.	.12	—	.15
Lactic, 22 per cent.....	lb.	.06	—	.06½
Nitric, 36 deg.....	lb.	.07½	—	.07½
Nitric, 42 deg.....	lb.	.08½	—	.09½
Oxalic, crystals.....	lb.	.43	—	.45
Phosphoric, 47 per cent-50 per cent.....	lb.	.07½	—	—
Picric.....	lb.	.63	—	—
Pyrogallol, resublimed.....	lb.	3.10	—	3.15
Sulphuric, 60 deg.....	ton	25.00	—	27.00
Sulphuric, 66 deg.....	ton	35.00	—	36.00
Sulphuric, oleum (Fuming), tank cars.....	ton	55.00	—	—
Tannic, U. S. P., bulk.....	lb.	1.30	—	1.35
Tartaric, crystals.....	lb.	.78½	—	.81
Tungstic, per lb. of W.....	lb.	1.80	—	1.90
Alcohol, grain, 188 proof.....	gal.	4.70	—	4.35
Alcohol, wood, 95 per cent.....	gal.	1.20	—	1.25
Alcohol, denatured, 180 proof.....	gal.	.95	—	1.00
Alum, ammonia lump.....	lb.	.04½	—	.04½
Alum, chrome ammonium.....	lb.	.18½	—	.19
Alum, chrome potassium.....	lb.	.23	—	.24
Alum, chrome sodium.....	lb.	.12½	—	.13
Alum, potash lump.....	lb.	.08	—	.09½
Aluminium sulphate, technical.....	lb.	.02	—	.02½
Aluminium sulphate, iron free.....	lb.	.03½	—	.04
Ammonia aqua, 26 deg. carboys.....	lb.	.14	—	.15
Ammonium carbonate.....	lb.	.12½	—	.13
Ammonium nitrate.....	lb.	.22	—	.24
Ammonium sulphate domestic.....	lb.	.07	—	.07½
Amyl acetate.....	gal.	4.75	—	5.00
Arsenic, white.....	lb.	.16½	—	.17
Arsenic, red.....	lb.	.65	—	.70
Barium carbonate, 99 per cent.....	ton	70.00	—	—
Barium carbonate 97-98 per cent.....	ton	65.00	—	—
Barium chloride.....	ton	73.00	—	83.00
Barium sulphate (Blanc Fixe, powder).....	lb.	.04	—	.04½
Barium nitrate.....	lb.	.11½	—	.12½
Barium peroxide, basis 70 per cent.....	lb.	.27	—	.27½
Bleaching powder, 35 per cent chlorine.....	lb.	.01½	—	.01½
Borax, crystals, sacks.....	lb.	.07½	—	.08½
Brimstone, crude.....	ton	60.00	—	65.00
Bromine, technical.....	lb.	.65½	—	.75½
Calcium, acetate, crude.....	lb.	.06	—	.06½
Calcium, carbide.....	lb.	.08½	—	.09
Calcium chloride, 70-75 per cent, fused, lump.....	ton	36.00	—	38.00
Calcium peroxide.....	lb.	1.60	—	1.70
Calcium phosphate.....	lb.	.33	—	.35
Calcium sulphate.....	lb.	—	—	—
Carbon bisulphide.....	lb.	.07½	—	.08½
Carbon tetrachloride, drums.....	lb.	.16½	—	—
Caustic potash, 88-92 per cent.....	lb.	.85	—	.87
Caustic soda, 76 per cent.....	lb.	.07½	—	.08
Chlorine, liquid.....	lb.	.16	—	.24
Cobalt oxide.....	lb.	1.40	—	1.50
Copperas.....	lb.	.01½	—	.01½
Copper carbonate.....	lb.	.30½	—	.32
Copper cyanide.....	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals.....	lb.	.09	—	.09½
Cream of tartar, crystals.....	lb.	.52	—	.53
Cresol salt, bags.....	lb.	.03½	—	.04
Formaldehyde, 40 per cent.....	lb.	.16	—	.17
Glauber's salt.....	lb.	.01½	—	.01½
Glycerine, bulk, C. P.....	lb.	.70	—	.71
Iodine, resublimed.....	lb.	3.50	—	3.7½
Iron oxide.....	lb.	.13	—	.13
Lead, acetate, white crystals.....	lb.	.17½	—	.18½
Lead arsenate.....	lb.	.15	—	.18
Lead nitrate.....	lb.	.17½	—	.18
Litharge, American.....	lb.	.10½	—	.11½
Lithium carbonate.....	lb.	1.50	—	2.00
Manganese dioxide, U. S. P.....	lb.	.48	—	.55
Magnesium carbonate, tech.....	lb.	.11	—	.12½
Nickel salt, single.....	lb.	.14	—	.16
Nickel salt, double.....	lb.	.11	—	.13
Phosphorus, red.....	lb.	1.70	—	—
Phosphorus, yellow.....	lb.	2.10	—	2.20

Potassium bichromate.	lb.	44	—	45
Potassium bromide granular.	lb.	1.35	—	1.40
Potassium carbonate calcined, 80-85 per cent.	lb.	70	—	75
Potassium chlorate, crystals.	lb.	54	—	55
Potassium cyanide, 98-99 per cent.	lb.	2.60	—	2.70
Potassium iodide.	lb.	2.90	—	3.00
Potassium muriate 80-85 p.c. basis of 80 p.c.	ton	325.00	—	350.00
Potassium nitrate.	lb.	28	—	30
Potassium permanganate.	lb.	3.85	—	4.00
Potassium prussiate, red.	lb.	2.70	—	2.80
Potassium prussiate, yellow.	lb.	1.25	—	1.30
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	300.00	—	325.00
Rochelle salts.	lb.	39	—	39½
Salammoniac, gray gran.	lb.	10½	—	11½
Salammoniac, white gran.	lb.	15	—	16
Salt soda.	100 lb.	1.20	—	1.25
Salt cake.	100 lb.	1.10	—	1.15
Silver cyanide, based on market price of silver.	oz.	—	—	—
Silver nitrate.	oz.	53	—	54½
Soda ash, 58 per cent. light, flat.	100 lb.	3.10	—	3.20
Soda ash, 58 per cent. dense, flat.	100 lb.	3.90	—	4.00
Sodium acetate.	lb.	13½	—	14
Sodium benzoate.	lb.	1.75	—	2.00
Sodium bicarbonate, domestic.	100 lb.	2.65	—	2.85
Sodium bicarbonate, English.	lb.	—	—	—
Sodium bichromate.	lb.	19½	—	21
Sodium bisulphite, powd.	lb.	64½	—	65
Sodium chloride.	lb.	24	—	25
Sodium cyanide.	lb.	54	—	55
Sodium fluoride, commercial.	lb.	18	—	18½
Sodium hyposulphite.	lb.	01¾	—	02
Sodium nitrate, 95%.	100 lb.	4.90	—	5.00
Sodium nitrite.	lb.	35	—	36
Sodium peroxide.	lb.	55	—	60
Sodium phosphate (tri.)	lb.	04¾	—	05
Sodium prussiate, yellow.	lb.	35	—	37
Sodium silicate, liquid.	lb.	04¼	—	04½
Sodium sulphide, 30 per cent. crystals.	lb.	02¼	—	02½
Sodium sulphide, 60 per cent. fused.	100 lb.	3.75	—	4.00
Sodium sulphite.	lb.	04	—	05½
Strontium nitrate.	lb.	25	—	30
Sulphur chloride, drums.	lb.	06	—	06½
Sulphur dioxide, liquid, in cylinders.	lb.	15	—	40
Sulphur, flowers, sublimed.	100 lb.	4.10	—	4.15
Sulphur, roll.	100 lb.	3.75	—	4.10
Sulphur, crude.	ton	60.00	—	65.00
Tin bichloride, 50 deg.	lb.	19½	—	20
Tin oxide.	lb.	64½	—	65
Zinc carbonate.	lb.	24	—	25
Zinc chloride.	lb.	15½	—	17
Zinc cyanide.	lb.	50	—	—
Zinc dust 350 mesh.	lb.	17	—	18
Zinc oxide, American process XX.	lb.	15½	—	16
Zinc sulphate.	lb.	06	—	06½

Coal Tar Products (Crude)

Benzol, pure, water white.	gal.	45	—	50
Benzol, 90 per cent.	gal.	50	—	52
Toluol, pure water white.	gal.	1.80	—	1.85
Xylol, pure, water white.	gal.	45	—	50
Solvent naphtha, water white.	gal.	18	—	22
Solvent naphtha, crude, heavy.	gal.	13	—	16
Cresote oil, 25 per cent.	gal.	33	—	35
Dip oil, 20 per cent.	gal.	29	—	30
Pitch, various grades.	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent.	lb.	60	—	65
Carbolic acid, crude, 25 per cent.	lb.	32	—	35
Cresol, U. S. P.	lb.	19	—	20

Intermediates, Etc.

Alpha naphthol, crude.	lb.	1.10	—	—
Alpha naphthol, distilled.	lb.	1.60	—	—
Alpha naphthylamine.	lb.	60	—	62
Aniline oil.	lb.	25	—	28
Aniline salts.	lb.	31	—	32
Anthracene, 80 per cent.	lb.	10	—	—
Benzaldehyde.	lb.	4.00	—	4.50
Benzidine, base.	lb.	1.60	—	1.80
Benzidine, sulphate.	lb.	1.40	—	1.50
Benzole acid.	lb.	2.00	—	2.25
Benzyl chloride.	lb.	1.75	—	2.00
Beta naphthol benzoate.	lb.	6.50	—	8.50
Beta naphthol, sublimed.	lb.	85	—	90
Beta naphthylamine com.	lb.	2.50	—	—
Dichlor benzol.	lb.	12	—	18
Diethylaniline.	lb.	3.75	—	4.25
Dinitro benzol.	lb.	34	—	50
Dinitrochlorbenzol.	lb.	42	—	44
Dinitronaphthalene.	lb.	55	—	60
Dinitrotoluol.	lb.	57	—	62
Dinitrophenol.	lb.	55	—	62
Dimethylaniline.	lb.	57	—	59
Diphenylamine.	lb.	1.00	—	1.10
H-acid.	lb.	3.00	—	3.50
Metaphenylenediamine.	lb.	1.75	—	1.80
Monochlorbenzol.	lb.	22	—	23
Naphthalene, flake.	lb.	09½	—	10
Naphthionic acid, crude.	lb.	1.50	—	1.75
Naphthylamine-di-sulfonio acid.	lb.	1.00	—	1.10
Nitro naphthalene.	lb.	45	—	50
Nitro toluol.	lb.	50	—	55
Ortho-amidophenol.	lb.	—	—	—
Ortho-toluidine.	lb.	85	—	90
Ortho-nitro-toluol.	lb.	75	—	1.00
Para-amidophenol, base.	lb.	4.00	—	5.00
Para-amido-phenol, H. Ch.	lb.	5.25	—	5.75
Paranitraniline.	lb.	1.10	—	1.15
Para-nitro-toluol.	lb.	1.50	—	1.60
Paraphenylenediamine.	lb.	3.50	—	4.00
Para-toluidine.	lb.	2.00	—	2.25
Phenol, U. S. P.	lb.	51	—	52
Resorcin, technical.	lb.	8.00	—	9.00
Resorcin, pure.	lb.	13.50	—	15.00
Salicylic acid.	lb.	1.25	—	1.35
Solol.	lb.	2.00	—	2.25
Sulphanilic acid.	lb.	32	—	35
Toluidine.	lb.	3.00	—	—
Toluidine-mixture.	lb.	75	—	85

Petroleum Oils

Crude (at the Wells)

Pennsylvania.	bbl.	3.50	—	—
Corning, Ohio.	bbl.	2.60	—	—
Somerset, Ky.	bbl.	2.40	—	—
Wooster, Ohio.	bbl.	2.38	—	—
Indiana.	bbl.	1.98	—	—
Illinois.	bbl.	2.12	—	—
Oklahoma and Kansas.	bbl.	2.00	—	—
Caddo, La., light.	bbl.	2.00	—	—
Corsicana, Tex., light.	bbl.	2.00	—	—
California.	bbl.	.98	—	1.32
Gulf Coast.	bbl.	1.00	—	—

Fuel Oil

New York.	gal.	10½	—	—
Pittsburgh.	gal.	07½	—	10
Oklahoma-Kans.	bbl.	70	—	1.55
Texas.	bbl.	1.60	—	—
Los Angeles.	bbl.	1.45	—	—
San Francisco.	bbl.	1.45	—	—

Gasoline (Wholesale)

New York.	gal.	24	—	—
Boston.	gal.	25	—	—
Pittsburgh.	gal.	24	—	—
Chicago.	gal.	21	—	—
Oklahoma.	gal.	23	—	—
San Francisco.	gal.	20	—	—

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.	gal.	13½	—	14
Cylinder, light.	gal.	21	—	26
Cylinder, dark.	gal.	18	—	19
Paraffine, high viscosity.	gal.	29½	—	30
Paraffine, .903 sp. gr.	gal.	21½	—	22
Paraffine, .865 sp. gr.	gal.	18½	—	19

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida.	gal.	44	—	—
Pine oil, steam distilled, sp. gr. 0.925-0.940.	gal.	52	—	—
Pine oil, destructively distilled.	gal.	48	—	53
Pine-tar oil, sp. gr. 1.025-1.035.	gal.	25½	—	—
Pine-tar oil, double refined, sp. gr. 0.965-0.990.	gal.	35	—	—
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works.	gal.	37	—	—
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works.	gal.	26	—	—
Pine tar, thin, sp. gr. 1.060-1.080.	gal.	22	—	—
Turpentine, crude, sp. gr. 0.980-1.000.	gal.	40	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990.	gal.	19	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08.	gal.	19	—	—
Wood creosote, ref. f.o.b. Florida.	gal.	50½	—	—

Vegetable and Other Oils

China wood oil.	lb.	21	—	22
Cottonseed oil, crude.	gal.	1.15	—	1.17
Linseed oil, raw, cars.	gal.	1.12	—	1.14
Peanut oil, crude.	gal.	1.25	—	—
Rosin oil, first run.	gal.	35	—	—
Rosin oil, fourth run.	gal.	66	—	—
Soya bean oil, Manchuria.	lb.	15	—	15½
Turpentine, spirits.	gal.	54½	—	—

Miscellaneous Materials

Barytes, floated, white, foreign.	ton	40.00	—	50.00
Barytes, floated, white, domestic.	ton	30.00	—	36.00
Beeswax, white, pure.	lb.	65	—	68
Carnauba wax, flor.	lb.	55	—	—
Casein.	lb.	22	—	30
Chalk, light, precipitated, English.	lb.	—	—	—
Feldspar.	ton	8.00	—	12.00
Fuller's earth, powdered.	100 lb.	1.00	—	1.50
Ozokerite, crude, brown.	lb.	65	—	75
Ozokerite, American, refined, white.	lb.	75	—	1.00
Red lead, dry, carloads.	lb.	10	—	11½
Rosin, 280 lb.	bbl.	6.75	—	—
Serpentine.	ton	10.00	—	12.50
Talc, American, white.	ton	15.00	—	18.00
White lead, dry.	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick.	net ton	Nominal	—	—
Chrome cement, Grecian.	net ton	Nominal	—	—
Clay brick 1st quality fireclay.	per 1000	50.00	—	55.00
Clay brick, second quality.	per 1000	35.00	—	40.00
Magnesite, raw.	ton	30.00	—	35.00
Magnesite, calcined.	ton	40.00	—	55.00
Magnesite, Grecian, dead burned.	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9x4½x2½.	net ton	135.00	—	140.00
Silica brick.	per 1000	50.00	—	60.00

Ferroalloys

Ferrocobaltitium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	160.00	—	—
Ferromanganese, per lb. of Cr.	lb.	35	—	40
Ferromanganese, domestic, delivered.	ton	300.00	—	—
Ferromanganese, English.	ton	375.00	—	—
Ferromolybdenum, per lb. of Mo.	lb.	4.00	—	4.40
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton	230.00	—	260.00
Ferrosilicon, 60 per cent, carloads, del., Pittsburgh.	ton	200.00	—	250.00
Ferrosilicon, 60 per cent, contract.	ton	100.00	—	150.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh.	lb.	2.40	—	2.60
Ferroumanganese, f.o.b. works, per lb. of U.	lb.	7.00	—	7.50
Ferrovandium, f.o.b. works.	lb.	3.25	—	3.50

Ores and Semi-finished Products

Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit.	ton	90	—	—
Manganese ore, 48 per cent and over, per unit.	ton	1.00	—	—
Manganese ore, chemical.	ton	\$100.00	—	—
Molybdenite, per lb. of MoS ₂ .	lb.	2.20	—	—
Tungsten, Scheelite, per unit of WO ₃ .	ton	26.00	—	—
Tungsten, Wolframite, per unit of WO ₃ .	ton	24.00	—	—
Uranium oxide, 96%.	lb.	3.25	—	3.60
Vanadium Pentoxide, 99%.	lb.	10.50	—	—
Pyrites, foreign.	unit	16	—	16½
Pyrites, domestic.	unit	11	—	12

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

The ADVANCE PAPER TUBE & CAN MANUFACTURING COMPANY, INC., New York. Capital, \$25,000. To manufacture paper, cardboard and kindred products. Incorporators are: L. Silverstein, D. Gluckstein and P. Rothberg, 132 Greene Street, New York.

The AGRICULTURAL CHEMICAL COMPANY, Memphis, Tenn. Capital, \$10,000. To manufacture chemicals and kindred products. Incorporators are: Henry L. Sanders, F. E. Brown, J. B. Kelly, Memphis, and others.

The AMERICAN GLASS COMPANY, Seattle, Wash. Capital, \$6,000. To manufacture glass and glass products. Incorporators are: James F. Dooley and Charles Holmberg, Seattle.

The AMERICAN LIME & POTASH PRODUCTS CORPORATION, Roanoke, Va. Capital, \$300,000. To manufacture lime, potash and their by-products. Incorporators are: F. M. Hughson, Roanoke, and E. S. Hamilton, Filbert, W. Va.

The AMERICAN STANDARD METAL PRODUCTS CORPORATION, Dover, Del. Capital, \$21,000,000. To manufacture metal products of various kinds.

The ANNISTON STEEL PRODUCTS COMPANY, Birmingham, Ala. Capital, \$3,000,000. To mine for manganese, iron, steel, zinc, copper, tungsten and kindred metals. Incorporators are: C. A. Bingham, Walter M. Hood, E. S. Center, M. F. Randall, P. C. Covington, W. R. Lloyd and T. L. Stewart, Birmingham.

The ARCANUM OIL, GAS & REFINING COMPANY, Arcanum, Ohio. Capital, \$250,000. To operate an oil refining works.

The HERMUDA OIL & GAS COMPANY, Tulsa, Okla. Capital, \$25,000. To operate an oil refining works and produce gas, etc. Incorporators are: J. E. Hildt, R. I. Taylor and F. M. Drane, Tulsa.

The BETZWOOD FILM COMPANY, Philadelphia, Pa. Capital, \$500,000. To manufacture motion picture films. Incorporators are: F. R. Hansell, Philadelphia; J. V. Pimm and S. C. Seymour, Camden, N. J.

The BIG SEVEN LEAD & ZINC COMPANY, Oklahoma City, Okla. Capital, \$100,000. To mine for lead, zinc and kindred metals. Incorporators are: W. W. Oder and John Weaver, Oklahoma City; J. W. Gillum, Erick, and Perry C. Burks, Texola.

The BUCYRUS STEEL COMPANY, Bucyrus, Ohio. Capital, \$50,000. To manufacture steel and steel products. Incorporators are: S. H. Tolles, W. T. Kinder, Ralph Burroughs, R. C. Hyatt and John M. Garfield, Bucyrus.

The BURLINGTON OIL & REFINING COMPANY, Oklahoma City, Okla. Capital, \$1,000,000. To develop oil lands, refine oil and produce gas. Incorporators are: W. D. King, R. R. Sims and H. W. Ferguson.

The CARLISLE TIRE & RUBBER COMPANY, Dover, Del. Capital, \$200,000. To manufacture rubber tires and rubber products. Incorporators: L. B. Phillips and J. B. Bailey, Dover, Del.

The COAL OIL MANIFOLD COMPANY, St. Louis, Mo. Capital, \$10,000. To manufacture kerosene engines, manifolds and kindred products. Incorporators: R. W. Morrison, Edward H. Gorse and W. S. McCall, St. Louis.

The COMMONWEALTH PRODUCTS CORPORATION, Dover, Del. Capital, \$100,000. To manufacture iron, zinc and copper products. Incorporators: W. S. Randall, Portland, Me.; F. A. Armstrong, Wilmington, Del., and Clement M. Egner, Elkton, Md.

The COMMONWEALTH SILICA COMPANY, Chicago, Ill. Capital, \$1,500,000. To mine for silica, lime and other substances. Incorporators: P. Zak and L. L. and B. F. Cowan, Chicago.

The CULVER SUPERIOR GLASS COMPANY, Westerville, Ohio. Capital, \$100,000. To manufacture glass, etc. Incorporators are: John H. Roush, Gustav Meyer, J. Z. Kroumm, R. B. Adams, William D. Shaw and Thomas A. Tussey, Westerville.

The DAVIS CARBURETOR SYSTEM COMPANY, Wilmington, Del. Capital, \$500,000. To manufacture automobile parts. Incorporators are: J. E. Wright, William F. O'Keefe and M. Gehrman, Wilmington.

The DELPHI INDEPENDENT OIL COMPANY, Delphi, Ind. Capital, \$20,000. To produce oil and kindred products. Incorporators: George Gay, Glen R. Cushman, James C. Smock and Grover C. Long.

The DRAWN METAL PRODUCTS CORPORATION, New York. Active capital, \$250,000. To manufacture metal products of various kinds. Incorporators are: C. A. Mezger, H. Osswald, T. F. Crean, 359 Parkside Avenue, Brooklyn.

The FLECKENSTEIN VISIBLE GASOMETER COMPANY, Wilmington, Del. Capital, \$200,000. To manufacture gasoline and other oil measuring devices.

The FREELAND FOUNDRY & MACHINE COMPANY, Dover, Del. Capital, \$50,000. To manufacture and repair engines of various kinds.

The HALE PETROLEUM COMPANY, Dover, Del. Capital, \$20,000,000. To refine oil, produce gas and their products.

The HAPGOOD OIL & DEVELOPMENT COMPANY, Oklahoma City, Okla. Capital, \$500,000. To acquire oil and gas lands and develop same. Incorporators: C. M. Hapgood, New Healdton, Okla.; J. S. Strong, Oklahoma City, and Fred A. Gillette, El Reno, Okla.

The HIGH PRODUCTS CHEMICAL COMPANY, Newark, N. J. Capital, \$100,000. To manufacture chemicals and allied products. Incorporators are: Carl Dorgschlag, William Gerlach and H. C. Pfaff, Newark.

The INTERNATIONAL SAFETY RAILWAY TIE COMPANY, Dover, Del. Capital, \$1,000,000. To manufacture railroad and railway ties of all kinds.

The JEANETTE OIL & GAS COMPANY, Jeanette, Pa. Capital, \$50,000. To develop oil and gas lands in Pleasant and Tyler Counties, W. Va. Incorporators: John W. Keltz, Henry Bozzan, R. M. Zimmerman, Jeanette; H. E. Marker and C. B. Hollingsworth, Greensburg, Pa.

The KING GLASS COMPANY, Kokomo, Ind. Capital, \$100,000. To manufacture glass of all kinds. Incorporators are: E. B. King, and C. D. and W. M. Wells, Kokomo.

The KANSAS LIGHT OIL COMPANY, Wilmington, Del. Capital, \$750,000. To manufacture petroleum, oils and all their by-products.

The LAMIE CHEMICAL COMPANY, Huntington, W. Va. Capital, \$50,000. To manufacture chemicals and allied products. Incorporators: R. D. Lamie, Huntington; A. T. Roberts, Marquette, Mich.; H. W. Shelton, Negaunee, Mich.; John Garvin, Ontonagon, Mich., and Dan H. Ball, Marquette, Mich.

The LLOYD CHEMICAL WORKS, INC., Belleville, N. J. Capital, \$20,000. To manufacture chemicals, dyes and allied products. Incorporators are: M. and A. Vandeweghe and Ellis Lloyd, Belleville.

The MISSOURI IRON & STEEL COMPANY, Dover, Del. Capital, \$6,000,000. To manufacture steel and iron products.

The MOSS-BELL CHEMICAL COMPANY, Haledon, N. J. Capital, \$100,000. To manufacture chemicals, dyestuffs and allied products. Incorporators: Percival J. Wood, Joseph Whitehead and Samuel Schiffer, Haledon.

The NATURAL CHEMICAL PRODUCTS CORPORATION, New York. Capital, \$2,500,000. To manufacture chemicals and chemical products. Incorporators are: S. B. Howard, L. H. Gunther and Joseph Curtin, New York.

The NITRO-PHOSPHO CORPORATION OF NEW YORK, Newark, N. J. Capital, \$125,000. To manufacture chemicals and their by-products. Incorporators: George R. Swain, C. Jacobs and J. I. Sipp, Newark.

The OKLAHOMA GAS GENERATOR COMPANY, Oklahoma City, Okla. Nominal capital, \$5000. To manufacture gas generating machinery. Incorporators are: E. E. Blake, E. H. Carter and E. A. Wales.

T. J. PARKER, INC., New York. Capital, \$10,000. To manufacture chemicals, etc. Incorporators: G. H. Town, T. J. Parker and E. S. Burke, 1146 Fifty-fifth Street, Brooklyn.

The JACK PATCH MANUFACTURING COMPANY, Dover, Del. Capital, \$24,500. To manufacture a special automobile tire re-

pair material. Incorporators are: J. R. and C. E. Jack and John A. Bower, Waukegan, Ill., and Thomas J. Killian and Louis B. Jolley, North Chicago, Ill.

The PHIO COLOR WORKS, New York. Capital, \$5,000. To manufacture dyestuffs and kindred products. Incorporators: L. W. Alexander, F. C. Simons and M. Winters, 595 Eastern Parkway, Brooklyn.

The POCONO OIL & COAL COMPANY, Paterson, N. J. Capital, \$500,000. To acquire oil and coal lands and develop same. Incorporators are: Sylvester J. Lane, William T. Armstrong and Albert E. Sleight, all of Paterson.

The PRODUCERS & REFINERS OIL COMPANY OF INDIANA, Warren, Ind. Capital, \$250,000. To sink and operate oil and gas wells. Incorporators are: H. H. Markey, James W. Cunningham and Glenn Brown, Warren.

The RICHEY CONSTRUCTION CORPORATION, New York. Capital, \$50,000. To construct and operate plants for the manufacture of gas, oil, etc.

The ROTARY TIRE & RUBBER COMPANY, Dover, Del. Capital, \$1,000,000. To manufacture automobile tires and other rubber products.

The SANITARY CANNING MACHINE COMPANY, Dover, Del. Capital, \$500,000. To manufacture special machinery for the canning of fruits, etc.

SLAVIN & SIPKIN, INC., Newark, N. J. Capital, \$10,000. To manufacture paints, varnishes, etc. Incorporators: R. and I. Slavin and A. Sipkin, Newark.

THE SOUTHERN FIBRE & MANUFACTURING COMPANY, Jacksonville, Fla. Capital, \$50,000. To manufacture fibre. Incorporators are: C. S. Anderson, Jay Lyon and E. L. Anderson, Jacksonville.

The SQUARE TURN TRACTOR COMPANY, Dover, Del. Capital, \$2,000,000. To manufacture tractors and tractor attachments. Incorporators are: L. B. Phillips and J. B. Bailey, Dover.

The STANDARD SHOE BUFFING MACHINE COMPANY, Dover, Del. Capital, \$500,000. To manufacture machinery for the buffing of shoes.

The VAN OILER COMPANY, Chicago, Ill. Capital, \$25,000. To manufacture oiling machinery. Incorporators are: H. Elmer Hudson, Henry C. Heinemann and John C. Teevan, Chicago.

The WALKER CHEMICAL COMPANY, Philadelphia, Pa. Capital, \$10,000. To manufacture chemicals. Incorporators are: F. R. Hansell, Philadelphia, and S. C. Seymour, Camden, N. J.

The WALLACE COMPANY, Newark, N. J. To manufacture chemicals and allied products. William H. Wallace, principal incorporator.

WEBSTER & COMPANY, Philadelphia, Pa. Capital, \$50,000. To manufacture chemicals and kindred products. Incorporators are: M. Mills, John Kearns and C. A. Murphy, Philadelphia.

Construction and Operation

Alabama

BIRMINGHAM.—The Lecroy Graphite & Mineral Company, recently incorporated with a capital of \$250,000, is planning for the installation of an initial plant for the development of its graphite properties in Clay County, to cost about \$50,000. Harry W. Myers is president.

ENSLEY.—The National Steel Products Company has had plans prepared for the erection of a new plant at Bessemer to be devoted to the manufacture of steel castings and railway appliances. A new 3-ton open-hearth furnace will be installed, and the initial works, which will be 40 x 150 ft., will have a capacity of 15 tons per day.

SHEFFIELD.—The United States Government has announced that a site has been selected on the Tennessee River, near Muscle Shoals, for the erection of its proposed experimental nitrate plant, which will cost approximately \$3,000,000. It is said the works will specialize in the manufacture of nitric acid and ammonia.

California

BERKELEY.—The Philadelphia Quartz Company is making rapid progress in the construction of its new plant at Fifth and Grayson Streets, and is planning to inaugurate operations at an early date. The company proposes to manufacture silicate of soda in its various forms. Alfred C. Elkington is president.

LOS ANGELES.—The Ventura Refining Company is building a new plant at Fillmore for the refining of oil and the manu-

facture of wax extracted from oil. The new works represent an investment of \$300,000. F. E. Snowden is manager.

LOS ANGELES.—The Damon Specialty Company, manufacturer of polishing products, is planning for the construction of a new reinforced-concrete plant to cost about \$35,000.

LOS ANGELES.—The R. W. Fridham Company, 903 North Main Street, manufacturer of paper boxes, will build a two-story brick addition to its plant, about 92 x 98 ft.

LOS ANGELES.—The California Burdett Oxygen Company will build a new one-story shop, about 57 x 61 ft., on Fifty-second Street, near Santa Fe Avenue.

MARTINEZ.—The Butters Syndicate, which recently acquired the plant of the Peyton Chemical Company, is making rapid progress in the construction of its new plant for the manufacture of chemicals, and expects to inaugurate operations within the next three months.

PIEDRA.—The Piedra Magnesite Company is making rapid progress in the erection of its new magnesite calcining plant. The magnesite reduction kiln has been completed, and the installation of the machinery in the new works will soon commence.

Colorado

DENVER.—The International Rubber Company, 1569 Broadway, is taking bids for the erection of a new four-story building, about 125 x 145 ft., at 999 South Acoma Street, to cost about \$100,000. Walter L. Rice, 1608 Broadway, is the architect.

Connecticut

BRIDGEPORT.—The Heppenstall Forge Company, 95 Howard Avenue, is building a new one-story addition to its plant, about 60 x 361 ft. The structure will cost about \$10,000.

BRIDGEPORT.—The Spring Perch Company, manufacturer of coach springs, is completing the erection of a new one-story plant, 130 x 360 ft., at Stratford. The new works will represent an investment of about \$100,000.

NEWINGTON.—P. Garvan, Inc., Bartholomew Avenue, has commenced the construction of a new two-story paper mill, about 75 x 147 ft., at Elmwood, near Newington, to cost \$50,000.

STAMFORD.—Baer Brothers, Canal Street, manufacturers of paints, bronze powders, etc., have commenced the construction of an addition to their plant to replace portion of works recently destroyed by fire.

WATERBURY.—The Waterbury Manufacturing Company is building a new six-story addition to its plant to be devoted to the manufacture of brass goods. The structure will cost \$100,000.

Delaware

WILMINGTON.—The Jessup & Moore Paper Company has commenced the construction of a new two-story reinforced-concrete and brick addition to its plant, about 40 x 150 ft., to cost \$30,000.

WILMINGTON.—The Electric Hose & Rubber Company, Twenty-first Street, is planning for improvements in its plant to cost \$20,000.

WILMINGTON.—The Fusey & Jones Company, Poplar Street, is said to be considering the construction of a new foundry addition to its plant to cost about \$75,000.

Florida

PENSACOLA.—The Pensacola Fertilizer & Oil Company is planning for the installation of new machinery in its local plant for the manufacture of oil and fertilizer from menhaden. F. W. Miller is president.

Illinois

CHICAGO.—Swift & Company is having plans prepared for the construction of a large fertilizer plant at Hammond, to cost about \$500,000. Charles H. Kane is engineer for the company.

CHICAGO.—The Octigan Drop Forge Company has had plans prepared for the erection of a new one-story machine shop, 50 x 100 ft., at its plant on Lowe Avenue.

CHICAGO.—The Ehmman Tire & Rubber Company, 144 West Twenty-seventh Street, has had revised plans prepared for the construction of a three-story and basement brick addition to its plant to cost about \$50,000. Dibelka, Flaks & Minchin, 130 North Fifth Avenue, are architects.

CENTRALIA.—The Centralia Envelope Company is making rapid progress in the construction of its new manufacturing plant and power house. When completed the works will cost \$75,000.

EAST ST. LOUIS.—The East St. Louis Cottonseed Oil Company is having plans prepared for the construction of a new two-story addition, about 500 x 700 ft.

JOLIET.—The Standard Paint Company has commenced the erection of a new roofing and paint manufacturing plant to cost \$500,000. Hanson & Peterson, South Desplaines Street, has the contract for construction.

Kansas

KANSAS CITY.—The Wyandotte County Gas Company is planning for extensive improvements and additions in its local plant, to include the installation of new machinery, laying of pipe lines and construction of pumping stations.

Kentucky

LOUISVILLE.—The Federal Chemical Company has had plans prepared for the erection of a new plant at Columbus, Ohio, adjoining its mixing works. The new factory will be devoted to the manufacture of sulphuric acid, and is estimated to cost \$300,000.

Louisiana

HARVEY.—Swift & Company have commenced the construction of a new local acid plant, comprising three buildings. The structures will be brick, stone and reinforced-concrete, and are estimated to cost \$200,000.

Maryland

BALTIMORE.—The Chemical Pigments Company, President Street, is planning for the installation of new machinery at its works, including electrical equipment.

BALTIMORE.—The Hess Steel Company is planning for the erection of an addition to its electric furnace on East Biddle Street at Loney Lane.

BALTIMORE.—The Standard Oil Company has had plans prepared for the erection of a new addition, five-story, about 38 x 130 ft., to its plant at Pratt and Penn Streets.

Massachusetts

BOSTON.—The American Agricultural Chemical Company has commenced the construction of a new one-story addition to its chemical plant at Portsmouth, N. H. Harry A. George, 92 State Street, Boston, is engineer.

WATERTOWN.—The United States Government has commenced the erection of its new foundry at the local arsenal. The structure will be brick, about 280 x 300 ft., and is estimated to cost about \$500,000.

Michigan

GRAND RAPIDS.—The Imperial Chemical Company has acquired the business of the Superior Laboratories Company, and will take over the plant and equip for the manufacture of an anti-rust preparation for stoves. The company is also planning to increase its capital stock.

DETROIT.—The McCord Manufacturing Company, manufacturer of railway specialties, has commenced the construction of a new one-story machine shop, about 40 x 80 ft., at its works on East Grand Boulevard.

MANISTIQUE.—The Manistique Pulp & Paper Company is building a new one and two-story paper and pulp mill, 20 x 36 ft., and 60 x 200 ft., respectively, at a cost of \$1,000,000. W. J. Murphy, Minneapolis Tribune, 57 South Fourth Street, Minneapolis, Minn., is president.

Minnesota

MINNEAPOLIS.—The Federal Steel & Machinery Company, Metropolitan Building, has awarded a contract to John Brickels, Waseca, Minn., for the erection of three machine shops, about 110 x 400 ft., and a two-story foundry, about 100 x 215 ft. F. E. McClure is manager.

Missouri

ST. LOUIS.—The Tri-City Steel Company, incorporated under Delaware laws with a capital of \$1,000,000, has completed negotiations for the purchase of eight and one-half acres of property in the industrial section of the city, and is planning for the immediate erection of a rolling mill and auxiliary structures to cost about \$100,000, which will be devoted to the manufacture of steel railroad ties, rail joints and other supplies.

Montana

BUTTE.—The Anaconda Copper Mining Company has acquired the interests of the Montana-Canadian Oil Company and is planning for extensive development of the gas fields at Sweet Grass. The company is also planning to construct pipe lines

to Great Falls, Helena and Anaconda, the gas being used for lighting and heating purposes in the smelters at Anaconda and Great Falls. It is said that the entire work will cost between \$10,000,000 and \$15,000,000. C. F. Kelley heads the company.

New Hampshire

BERLIN.—The International Paper Company, 30 Broad Street, has commenced the construction of a new one-story filtration plant, about 30 x 40 ft., at its works. The structure will cost \$15,000. The H. P. Cummings Construction Company, Ware, Mass., is the contractor.

New Jersey

JERSEY CITY.—William T. Baker, Inc., manufacturer of varnishes, etc., has awarded a contract for the erection of a new one-story reinforced-concrete factory building on Suydam Avenue, near Communipaw Avenue.

NEWARK.—The Union Smelting & Refining Company, Avenue D and Fourteenth Street, New York, is making rapid progress in the construction of its new plant on St. Charles Street. The entire works will cover about five acres of land, and are estimated to cost \$500,000. L. D. Waixel is president.

NEWARK.—The Barlow Foundry Company has had plans prepared for the erection of a large addition, about 59 x 100 ft., to its works in Hunter Street, near New Jersey Railroad Avenue, to cost about \$20,000.

NEWARK.—The United Color & Pigment Company has taken bids for the erection of a new manufacturing plant on Evergreen Avenue. Percy B. Taylor, Essex Building, is architect and engineer.

NEWARK.—The Butterworth-Judson Company, manufacturer of chemicals, has taken out a building permit for the erection of a new one-story addition to its plant on Avenue R, to cost about \$10,000.

IRVINGTON.—The Irvington Insulator & Varnish Works, Tremont Avenue, have had plans prepared for the construction of a new one-story factory, about 100 x 200 ft., to cost \$25,000. The D. A. Hopper Company, Union Building, Newark, is architect.

LINDEN.—Fire recently destroyed the plant of the Transatlantic Chemical Company, Elizabeth Avenue and Stiles Street, with loss estimated at \$50,000.

KEYPORT.—The Reliance Rubber Company has completed alterations and improvements in its factory on Manchester Avenue, and inaugurated operations for the manufacture of rubber sundries. The company was formerly located at Hoboken.

PERTH AMBOY.—A new one-story power plant, 60 x 70 ft., will be erected by the American Smelting & Refining Company at its Maurer works. Headquarters of the company are at 120 Broadway, New York.

GLASSBORO.—The Owen Glass Company is rapidly completing its new plant, which has been in course of construction for the past year, and is planning to inaugurate operations within a few months. The entire works have cost approximately \$1,000,000.

TRENTON.—The Empire Tire & Rubber Company has commenced the erection of a new one-story brick and steel factory, about 90 x 320 ft., to cost \$40,000. W. A. K. Bugbee & Company, 206 East Hanover Street, is the contractor.

New York

NEW YORK.—The Linde Air Products Company, 30 East Forty-second Street, has acquired a site at Norfolk, Va., and is planning for the erection of a new plant for the manufacture of oxygen and other air products for industrial service.

LONG ISLAND CITY.—The Continental Varnish Company has filed plans for the construction of a new plant at Varick Avenue and Ingraham Street, on property, about 200 x 275 ft., recently acquired. The works will cost \$60,000.

COLLEGE POINT.—Fire, Oct. 13, destroyed the plant of the British-American Chemical Company, on Third Avenue and Flushing Bay, with loss estimated at \$250,000.

ROCHESTER.—The Eastman Kodak Company, 343 State Street, has awarded a contract for the construction of a one-story paper burning mill, about 40 x 75 ft., at Kodak Park. A. Friederichson & Sons Company, 710 Lake Avenue, is the contractor.

SYRACUSE.—The Penman Littlehales Chemical Company, Spring Street, has had plans prepared for the erection of an addition and improvements to its plant to cost about \$25,000.

BUFFALO.—The Greater American Chemical Company has awarded a contract to the Peckham Construction Company, Mutual Life Building, for the erection of a new two-story reinforced concrete factory, about 30 x 60 ft., at Colgate Street and South Park Road.

North Carolina

GOLDSBORO.—Fire, October 14, destroyed the entire plant of the Southern Cotton Oil Company, with loss estimated at \$300,000.

Ohio

BARBERTON.—The Semi-Steel Foundry Company has commenced the erection of a new foundry and machine shop at its plant. The structures will be of brick, steel and concrete, and will cost \$150,000.

BUCYRUS.—The American Clay Manufacturing Company has perfected arrangements for increasing the capacity of its plant, and is planning for the erection of a new grey iron foundry and steel plant.

MASSILON.—The Massilon Steel Castings Company, recently organized, has commenced the erection of a new plant, the main building of which will be of brick and steel, about 100 x 100 ft.

WESTERVILLE.—The Culver Superior Glass Company is planning for the erection of a large plant for the manufacture of automobile lenses, watch crystals, mirrors and other glass products. W. D. Shaw of Columbus is president.

YOUNGSTOWN.—The National Carbon Company, Inc., the Union Carbide Company, the Linde Air Products Company, and the Presto-O-Lite Company, have been merged into one company for the manufacture of calcium carbide and all gas-producing materials and gas, machinery for gas production, lighting carbons, electric batteries and kindred products.

Oklahoma

PICHER.—The Fort Worth Lead & Zinc Company has commenced the erection of a new concentrating plant, which will have a capacity of approximately 200 tons per shift. Two shafts are now being sunk, and an ore body of about thirty-five feet thick was shown by preliminary drilling.

Pennsylvania

PHILADELPHIA.—The Penn Chemical Company, 1232 Washington Avenue, has commenced the construction of a new one-story addition to its plant, about 25 x 45 ft., to cost \$25,000.

PHILADELPHIA.—The Tioga Steel & Iron Company has acquired five acres of land near its factory at Fifty-first Street and Grays Avenue, and is planning for the erection of a large plant for the manufacture of guns for the government.

PHILADELPHIA.—Baxter, Kelly & Faust have awarded a contract for the construction of a one-story brick lime house at C and Tioga Streets. The Fred A. Havens Company, Philadelphia, is the contractor.

CHESTER.—Fire recently destroyed a portion of the plant of the Sun Oil Company, with loss estimated at \$60,000.

CHELTENHAM.—Hoffman, DeWitt & McDonough Company, Inc., manufacturer of chemicals, etc., has awarded a contract to the William Linker Company, 831 Cherry Street, Philadelphia, for the erection of a new boiler house, calender room and mill.

YORK.—The Cochran Brass Foundry Company, East Wallace & Sherman Streets, has awarded a contract to A. M. Hake & Company, York, for the erection of a large addition to its plant. The company has received a large order from the Government for castings for submarine service.

KANE.—Fire recently destroyed a portion of the plant of the Keller Chemical Company, Ltd., with loss estimated at \$100,000. Headquarters of the company are at Wetmore.

PITTSBURGH.—The American Sheet & Tin Plate Company is making extensive improvements to its plant at Leechburg.

Rhode Island

PROVIDENCE.—John D. Lewis, manufacturer of chemicals, dyes, etc., is planning for the establishment of a new branch in the Drexel Building, Philadelphia, Pa. George A. Street of Philadelphia will be in charge of the new office.

Texas

HOUSTON.—The new plant of the Petroleum Refining Company on the Ship Channel is being rushed to completion as rapidly as possible. Workmen are busy in day and night shifts, and it is expected

to complete the works within the next month. When completed, the plant will include a concrete steam plant, machine shop, carpenter shop, and auxiliary structure.

HOUSTON.—Fire recently destroyed the plant of the Wortham Bag & Fiber Company, 501 Washington Avenue, with loss estimated at \$100,000. It is said the works will be immediately rebuilt.

Washington

SEATTLE.—The Aurora Foundry Company has inaugurated operations in its new plant on tract 6 of the Port Commission's Canal Waterway. The company will specialize in the manufacture of steel castings.

TACOMA.—The Bilrowe Alloys Company is planning to double the capacity of its plant to provide for increased demands. The company will also make extensive improvements in its furnaces.

West Virginia

BRAMWELL.—The National Carbide Company has awarded a contract to Westinghouse, Church, Kerr Company, 37 Wall Street, New York, for the erection of a new chemical plant to cost \$500,000.

HUNTINGTON.—The Virginian Pottery Company, 528 Fourth Street, have had plans prepared for the erection of a new factory, about 132 x 408 ft., to be devoted to the manufacture of electric insulators. The structure will cost about \$35,000.

Wisconsin

CUDAHY.—The Federal Rubber Company has awarded a contract for the erection of a new six-story addition, about 45 x 300 ft., to its plant, to provide for increased capacity.

MILWAUKEE.—The Globe Seamless Tube Company, Thirty-fifth and Burnham Streets, has commenced the erection of a new one-story addition, about 48 x 50 ft., to its plant, to cost about \$7,000.

MENASHA.—The Edgewater Paper Company is making rapid progress in the construction of a new one-story addition to its plant, about 48 x 150 ft. The structure will cost \$9,000. C. R. Mayer & Son, Oshkosh, are the architects.

Manufacturers' Notes

THE VALLEY STEEL COMPANY, St. Louis, Mo., has in operation a Bally Electric Furnace for heat treating car axles.

THE MERRILL METALLURGICAL CO., San Francisco, Cal., has been appointed Pacific Coast representative of the Jonathan Bartley Crucible Co. of Trenton, N. J.

NAVY BUYS ELECTRIC FURNACES.—The Navy has placed contracts for seven more six-ton electrical furnaces, making 11 purchased recently. Each calls for \$50,000, approximately, or a total payment of \$550,000. Three will be installed at government's Charleston, W. Va., plant, three at Watertown arsenal and one at Washington Navy Yard.

MR. LOUIS WILPUTTE announces that he has resigned the presidency of the Otto Coking Company, Inc., and has formed with American capital exclusively the Wilputte Coke Oven Corporation, retaining the entire organization formerly operated by the Otto company. Offices will be maintained for the present at No. 6 Church Street, New York.

THE AMERICAN PULVERIZER COMPANY has moved its office and factory from East St. Louis, Ill., to St. Louis, Mo., in order to provide larger quarters and improved facilities for handling its business.

THE PFAUDLER CO., Rochester, N. Y., has established the following branch offices: Pittsburgh, Pa., 1502 Oliver Building. Mr. James H. Charity, representative; Detroit, Mich., 1946 Penobscot Building. Mr. George M. Scott, representative.

WESTINGHOUSE ELECTRIC & MFG. COMPANY ANNOUNCES WAGE INCREASE.—Another increase in wages for shop employees aggregating nearly \$2,000,000 a year has just been announced by the Westinghouse Electric & Manufacturing Company. Effective October 16, all employees observing shop hours, except munition workers, will receive an additional bonus of 10 per cent if they are on a salary or time-rate basis, and of 7 per cent if they are on a piece, premium or task basis. The company has 20,000 employees.

PHILADELPHIA BRANCH.—Marden, Orth & Hastings Corporation have recently opened a new branch in the Widener Building, Philadelphia. The branch is in charge of Mr. J. Raymond Murphy, who has had a very wide acquaintance with the trade in the Philadelphia district.

THE ELECTRIC FURNACE CONSTRUCTION CO., 1304 Finance Building, Philadelphia, makes the following announcement of contracts closed for Greaves-Etchells electric furnaces:

Steel Corporation of South Africa—Two five-ton furnaces.

Sociedad Espanola de Construcción Naval Madrid—Two ten and one six-ton furnaces. Singer Manufacturing Co., New York—One six-ton furnace.

A furnace of two tons capacity was recently started up at Messrs. Kayser Ellison & Co., Sheffield, on special aeroplane steels and twenty-eight heats of sound steel were obtained from cold new furnace started Monday noon to Friday evening. The firm reported the furnace could have been worked quicker, but the men were not accustomed to such rapid melting with a new furnace.

The company announces that Mr. Frank W. Brooke, who was originally connected with the Gronwall Dixon furnace at Detroit and latterly as metallurgist for the Ludlum Steel Works and the Ludlum Electric Furnace Co., is joining their staff as director. Mr. Brooke will be responsible for the construction and running of the Greaves-Etchells furnaces. He will be assisted in the erection and installation by Mr. G. W. Ketter, B. Sc., who has installed a great many of the electric furnaces now running and who has just completed the installation of ten furnaces for the British Forgings Co., Toronto.

THE LOCOMOTIVE PULVERIZED FUEL CO., 30 Church Street, New York, announces that the Milwaukee Electric Railway & Light Company have recently placed with this company an order to equip with our apparatus for the burning of pulverized fuel 25,000 hp. of boilers at their Onelda Street plant.

This is the first central station plant to be so equipped, and the largest amount of boiler horsepower that has yet been equipped with powdered coal.

THE CONTINUOUS ZINC FURNACE CO., Hartford, Conn., which developed at its plant on Broad Street the "Johnson" process of electric smelting zinc-lead ores, saving all the values, zinc, copper, lead, gold and silver, has sold the major right, title and interest in this process to the American Smelting & Refining Company, the largest interest in the lead and silver business in the world. This company will exploit the process, carry along a commercial test and build a commercial furnace at one of its Western plants.

Manufacturers' Catalogs

THE INDUSTRIAL ELECTRIC FURNACE COMPANY, Chicago, Ill., has just published a new bulletin, No. 40, October, 1917, describing up-to-date facts on electric furnace for the melting and refining of ferrous and non-ferrous metals, giving photographs and diagrams.

JONATHAN BARTLEY CRUCIBLE CO., Trenton, N. J., has just issued a new catalog showing various types and sizes of graphite crucibles and specials used in foundry practice.

THE AMERICAN STEEL EXPORT COMPANY, New York City, has issued a new twenty-four page pamphlet giving the groups of countries and lists of materials affected by the President's proclamation and subsequent orders together with facsimiles of forms prescribed and an explanation of their use.

THE ARMSTRONG CORK & INSULATION COMPANY, Pittsburgh, Pa., has issued a little pamphlet on "Nonpareil Insulating Brick for Boiler Settings."

THE UNITED STATES SILICA COMPANY has issued a booklet describing "Flint-Shotting," a form of sand blasting. The booklet is called "Little Journeys of the Flint Shot Man." The company's headquarters are in Chicago, Ill.

KAESTNER & HECHT CO., Chicago, Ill., has issued a book entitled "Paint Machinery."

THE GOLDSCHMIDT THERMIT COMPANY, New York City, has issued Pamphlet No. 20, third edition, describing thermit carbon-free metals.

THE WORTHINGTON PUMP & MACHINERY CORPORATION, New York City, has issued the following: Bulletin No. 8-112, illustrating and describing Snow oil pumps; Bulletin No. W-500, describing pot valve pressure pumps; and Bulletin W-308, covering "Duplex" piston pattern pumps.

THE LINK-BELT COMPANY, Chicago, Ill., has issued Folder No. 340 describing the sand and gravel washery at the Raritan Ridge Clay Company, and Book No. 323, on rope tramway system, and Book No. 325, "Tippie" at Powhatan in Pocahontas Field.